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DEPARTMENT OF THE ARMY **02513.TD (October 1992)**
U.S. ARMY CORPS OF ENGINEERS **REV OCT 94**

TULSA DISTRICT GUIDE SPECIFICATION

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SECTION 02513

CONCRETE PAVEMENT FOR ROADS AND AIRFIELDS

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NOTE: This guide specification covers the requirements for lean concrete bases (also known as "Econocrete") and heavy duty concrete construction for roads and airfields. This guide specification is to be used in the preparation of project specifications in accordance with ER 1110-345-720.

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PART 1 GENERAL

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NOTE: See Additional Notes A, B and C.

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1.1 SUMMARY (NOT APPLICABLE)

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NOTE: Paragraph "1.1 SUMMARY (Not Applicable)" is required in all CEGS in order to make CEGS compatible with guide specifications of other agencies within the SPECSINTACT system. However, this paragraph is not to be included in Corps of Engineers project specifications.

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1.2 REFERENCES

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NOTE: Issue (date) of references included in project specifications need not be more current than provided by the latest change (Notice) to this guide specification.

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The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 544.2R	(1989) Measurement of Properties of Fiber Reinforced Concrete
ACI 544.3R	(1984; R 1988) Specifying, Mixing, Placing, and Finishing Steel Fiber Reinforced Concrete

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 53	(1990b) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
ASTM A 184	(1990) Fabricated Deformed Steel Bar Mats for Concrete Reinforcement
ASTM A 185	(1990a) Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
ASTM A 497	(1990b) Steel Welded Wire Fabric, Deformed, for Concrete Reinforcement
ASTM A 615	(1992b) Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM A 616	(1992) Rail-Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A 617	(1992) Axle-Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM C 29	(1991a) Unit Weight and Voids in Aggregate
ASTM C 31	(1991) Making and Curing Concrete Test Specimens in the Field
ASTM C 33	(1992a) Concrete Aggregates
ASTM C 70	(1979; R 1992) Surface Moisture in Fine Aggregate
ASTM C 78	(1984) Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
ASTM C 94	(1992a) Ready-Mixed Concrete
ASTM C 117	(1990) Materials Finer Than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 123	(1992) Lightweight Pieces in Aggregate
ASTM C 136	(1992) Sieve Analysis of Fine and Coarse Aggregates
ASTM C 142	(1978; R 1990) Clay Lumps and Friable Particles in Aggregates

ASTM C 143	(1990a) Slump of Portland Cement Concrete
ASTM C 144	(1993) Aggregate for Masonry Mortar
ASTM C 150	(1992) Portland Cement
ASTM C 171	(1992) Sheet Materials for Curing Concrete
ASTM C 172	(1990) Sampling Freshly Mixed Concrete
ASTM C 173	(1993) Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C 174	(1991) Measuring Length of Drilled Concrete Cores
ASTM C 231	(1991b) Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 260	(1986) Specification for Air-Entraining Admixtures for Concrete
ASTM C 295	(1990) Petrographic Examination of Aggregates for Concrete
ASTM C 494	(1992) Chemical Admixtures for Concrete
ASTM C 566	(1989) Total Moisture Content of Aggregate by Drying
ASTM C 595	(1993) Blended Hydraulic Cements
ASTM C 618	(1993) Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
ASTM C 881	(1990) Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C 989	(1989) Ground Granulated Blast-Furnance Slag for Use in Concrete and Mortars
ASTM D 98	(1993) Calcium Chloride
ASTM D 1751	(1983; R1991) Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D 1752	(1984; R1992) Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D 2628	(1991) Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements

ARMY CORPS OF ENGINEERS (COE)

COE CRD-C 55	(1985) Within-Batch Uniformity of Freshly Mixed Concrete
COE CRD-C 95	(1989) Concrete Plant Standards
COE CRD-C 100	(1975) Sampling Concrete Aggregate and Aggregate Sources, and Selection of Material for Testing
COE CRD-C 104	(1980) Calculation of the Fineness Modulus of Aggregate
COE CRD-C 112	(1969) Surface Moisture in Aggregate by Water Displacement
COE CRD-C 119	(1953; Rev 1963) Flat and Elongated Particles in Coarse Aggregate
COE CRD-C 143	(1962) Meters for Automatic Indication of Moisture in Fine Aggregate
COE CRD-C 300	(1990) Membrane-Forming Compounds for Curing Concrete
COE CRD-C 400	(1963) Water for Use in Mixing or Curing Concrete
COE CRD-C 572	(1974) Polyvinylchloride Waterstop

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST PB 90-184961	(1992) NIST Handbook 44: Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices

1.3 UNIT PRICES

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NOTE: Delete this paragraph for lump sum construction project.

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1.3.1 Measurement

1.3.1.1 Concrete

Concrete shall be measured in place in cubic yards [including monolithic curb] placed in the completed and accepted pavements in accordance with the dimensions and cross sections shown on the plans. No deductions will be made for rounded or beveled edges or the space occupied by pavement reinforcement, dowel bars, tie bars, or electrical conduits, nor for any void, drainage, or other structure extending into or through the pavement slab, measuring 3 cubic feet or less in volume.

1.3.1.2 Cement

Cement shall be measured in hundredweights (cwt) of portland cement used in the completed and accepted pavements. No payment will be made for wasted cement nor for cement used for the convenience of the Contractor. Measurements shall be made by multiplying the weight in pounds of cement required by the mixture proportions per cubic yard by the number of cubic yards placed within the pavement and then dividing by 100.

1.3.1.5 Steel Reinforcement

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NOTE: If only a thin bonded rigid overlay is to be used, this paragraph will be deleted.

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Fabricated steel bar or rod mats or welded steel wire fabric for reinforcement shall be measured by the square yard. Steel reinforcement shall be measured by the actual number of square yards of the completed and accepted pavement in which the reinforcement has been incorporated. No additional payment will be made for steel reinforcement used in lapping sections of reinforcement that exceed the length of the lap shown.

1.3.2 Payment

1.3.2.1 Concrete

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NOTE: If only a thin bonded rigid overlay is to be used, this paragraph will be deleted. If recycled concrete is to be used, choose the second paragraph and table.

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Concrete for pavement will be paid for at the contract unit price for "Concrete Pavement". The unit price shall include the cost to complete the concrete work including [steel reinforcement,] dowels and tie bars but does not include the cost for cement. When the pavement thickness deficiency exceeds the permissible tolerances as speacified in Paragraph "Pavement Quality Control", payment will be made at an adjusted price as specified below:

Pavements 8 Inches or Less In Thickness

Deficiency in Thickness (Inches)	Percent of Contract Unit Price Allowed
0.00 to 0.24	100
0.25 to 0.49	65
0.50 or greater	0

Pavements Over 8 Inches In Thickness

Deficiency in Thickness (Inches)	Percent of Contract Unit Price Allowed
0.00 to 0.24	100
0.25 to 0.49	75
0.50 to 0.74	50
0.75 or greater	0

1.3.2.4 Cement

Cement will be paid for at the contract unit price for "Cement", which price includes all costs for handling, hauling, and storage at the site.

1.3.2.6 Steel Reinforcement

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NOTE: If only a thin bonded rigid overlay is to be used, this paragraph will be deleted.

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The quantity of welded steel wire fabric or fabricated steel bar or rod mats measured as specified above will be paid for at the contract unit price for "Steel Reinforcement", which price includes all costs of furnishing and placing in the concrete pavements.

1.4 SUBMITTALS

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NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary factors in determining if a submittal for the item should be required.

Indicate submittal classification in the blank space using "GA" when the submittal requires Government approval or "FIO" when the submittal is for information only.

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Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01300SUBMITTAL DESCRIPTIONS:

SD-01 Data

Equipment and Methods; [_____].

A list of make, type, capacity, and number of all equipment to be used on the job. Procedures and test reports in accordance with paragraph APPROVAL OF PLANT EQUIPMENT AND CONSTRUCTION METHODS.

SD-09 Reports

Material Acceptance Testing; [_____].

Manufacturer's certified test reports on epoxy-resin material, showing that specific lots or batches, from which the material for this project is obtained, conform to the requirements of these specifications. Certified copies of aggregate tests and concrete mixture proportioning made by the laboratory, prior to use in the work.

SD-14 Samples

Material Acceptance Testing; [_____].

Samples of approved aggregates, taken under the supervision of the Contracting Officer in accordance with COE CRD-C 100, accompanied by test reports indicating conformance with grading requirements specified. Samples of materials other than aggregates shall be representative of those proposed for the project and shall be accompanied by the manufacturer's test reports indicating compliance with applicable specified requirements.

SD-18 Records

Material Acceptance Testing; [_____].

Results of tests conducted at the project site

1.5 MATERIAL ACCEPTANCE TESTING

1.5.1 Preconstruction Sampling and Testing

1.5.1.1 Aggregates

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NOTE: See Additional Note D.

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Aggregates shall be produced from the sources approved in accordance with the technical provisions herein. Sources from which aggregates are obtained shall be designated by the Contractor and samples representative of aggregates to be used shall be furnished the Contracting Officer within 15 days after Notice to Proceed, without cost to the Government. Samples shall be taken under the supervision of the Contracting Officer. Tests will be conducted by and at the expense of the Government. A maximum of 75 days will be required to complete evaluation of the aggregate.

[Tests for evaluation of aggregates and proportioning of concrete mixtures shall be made by an approved commercial testing laboratory at no expense to the Government. The Government will be responsible for all airfield pavement sampling and testing regardless of the size of the project. Test methods used for determining suitability of aggregate shall be as specified herein. Tests shall include but are not limited to the following:

Test	Approx. No. of workdays req'd.

Elem. Tests - Coarse Aggregate - (Sieve Analysis, Specific Gravity, Absorption Sulfate Soundness and Abrasion Resistance)	15
Elem. Tests - Fine Aggregate - (Sieve Analysis, Specific Gravity, Absorption Sulfate Soundness and Organic Impurities)	15-30
Unsound or Lightweight Particles	5
Particle Shape	5
Aggregates for Airfield Pavements (Deleterious Substances, Lightweight Particles)	10
Petrographic Analysis - Fine Aggregate	10
Petrographic Analysis - Coarse Aggregate	10

Sources from which aggregates are obtained and the commercial laboratory shall be selected and notification thereof furnished the Contracting Officer within 15 days after award of contract.]

1.5.1.7 Sample for Mixture Proportioning Studies

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NOTE: Approved aggregate sources paragraph for SPECIAL CLAUSES is given in ER 1180-1-1, paragraph 7-670.2. Evaluation of aggregates and concrete mix designs for projects requiring 1600 cubic yards or less of concrete except airfield paving will be performed by an approved commercial testing laboratory at no expense to the Government. In this case, this paragraph will be deleted.

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At least 60 days in advance of the time when placing of concrete is expected to begin, samples of representative materials proposed shall be delivered to the Corps of Engineers, Southwestern Division Laboratories, 4815 Cass Street, Dallas, TX., 75235 by the Contractor at his expense. Samples of approved aggregates shall be taken under the supervision of the Contracting Officer in accordance with CRD-C 100, accompanied by test reports indicating conformance with grading requirements specified. Samples of materials other than aggregates shall be representative of those proposed for the project and shall be submitted accompanied by the manufacturer's test reports indicating compliance with applicable specified requirements. Quantities of materials required shall be as follows:

Material	Quantity
Coarse aggregate 1-1/2 inch nominal maximum size	7,000 pounds

Coarse aggregate 3/4-inch nominal maximum size	7,000 pounds
Fine aggregate	4,000 pounds
Cement	1,500 pounds
Pozzolans	500 pounds
Air-entraining admixture	2 quarts
Other admixtures (each)	1 gallon

1.5.2 Acceptance Sampling and Testing During Construction

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NOTE: See Additional Note F.

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1.5.2.1 Aggregates

During construction, aggregates shall be sampled for acceptance testing before delivery to the mixer to determine compliance with specification provisions. The Contractor shall provide facilities and labor necessary for the ready procurement of representative samples. Samples delivered to the mixer shall be obtained when directed by the Contracting Officer and under his supervision. The Government will test such samples at its expense. Tests of aggregates at various stages in the process and handling operations will be made at the discretion of the Contracting Officer.

1.5.2.2 Cement

Cement will be sampled at the mill or shipping point and at the site of the work and tested by and at the expense of the Government. If tests prove that a cement that has been delivered is unsatisfactory, it shall be promptly removed from the site of the work. Cement that has not been used within 6 months after testing will be retested at the expense of the Contractor when directed by the Contracting Officer and shall be rejected if test results are not satisfactory. The cost of testing cement excess to the project requirements will also be at the expense of the Contractor. The charges for testing cement at the expense of the Contractor will be deducted from the payments due the Contractor at a rate of $1.20 per hundredweight of cement represented by the tests.

1.5.2.3 Prequalified Cement Sources

Cement shall be delivered and used directly from a mill of a producer designated as a qualified source. Samples of cement for check testing will be taken at the project site or the concrete producing plant by a representative of the Contracting Officer for testing at the expense of the Government. A list of prequalified cement sources is available from the Commander and Director, U.S. Army Engineer Waterways Experiment Station (ATTN: WESSC), P. O. Box 631, Vicksburg, Mississippi 39180.

1.5.2.4 Other Cement Sources

The sampling, testing, and shipping inspection from the point of sampling when the point of sampling is other than at the site of the work will be made by, or under the supervision of, the Government and at its expense. Cement meeting all other requirements may be accepted before the required 7-day age when the strength is equal to or greater than the 7-day requirement. In the event of failure, the cement may be resampled and tested at the request of the Contractor and at the Contractor's expense. When the point of sampling is other than at the site of the work, the fill gate or gates of the sampled bin shall be sealed and kept sealed until shipment from the bin has been completed. Sealing of the fill gate or gates and of conveyances used in shipment shall be done by or under the supervision of the Government. Conveyances will not be accepted at the site of the work unless received with all seals intact. If tested cement is rehandled at transfer points, the extra cost of inspection shall be at the Contractor's expense.

1.5.2.5 Pozzolan Sampling

Pozzolan will be sampled at the source and stored in sealed bins pending completion of certain tests. When determined necessary, pozzolan will also be sampled at the site. All sampling and testing will be performed by and at the expense of the Government. Release for shipment and approval for use will be based on compliance with 7-day lime-pozzolan strength requirements and other physical, chemical, and uniformity requirements for which tests will be completed by the time the 7-day lime-pozzolan strength test is completed, as well as on continuing compliance with the other requirements of the specifications. If the samples from a bin fail, the contents of the bin will be resampled and tested at the Contractor's expense. In this event, pozzolan shall be sampled as it is loaded into cars or trucks, provided they are kept at the source until released for shipment. Unsealing and resealing of bins and sealing of shipping conveyances will be done by or under the supervision of the Government. Shipping conveyances will not be accepted at the site of the work unless they are received with all seals intact. If pozzolan is damaged in shipment, handling, or storage, it shall be promptly removed from the site of the work. Pozzolan not used within 6 months after testing will be retested at the expense of the Contractor when directed by the Contracting Officer and shall be rejected if the test results are not satisfactory. If tested pozzolan is rehandled at transfer points, the extra cost of inspection will be at the Contractor's expense. The charges for testing pozzolan at the expense of the Contractor will be deducted from the payments due the Contractor at a rate of $2.00 per ton.

1.5.2.6 Admixtures

The Contractor shall provide satisfactory facilities for ready procurement of adequate test samples. Sampling and testing of an admixture will be by and at the expense of the Government. Tests will be conducted with materials proposed for the project. An air-entraining admixture that has been in storage at the project site for longer than 6 months or that has been subjected to freezing will be retested at the expense of the Contractor.

1.5.2.7 Curing Compound

The Contractor shall provide satisfactory facilities for ready procurement of adequate test samples. The sampling and testing will be by and at the expense of the Government.

1.5.2.8 Epoxy-Resin Material

At least 30 days before the material is used, the Contractor shall submit certified copies of test results showing that the specific lots or batches from which the material is obtained have been tested by the manufacturer and that the material conforms to the requirements of these specifications. When epoxy resin arrives at the jobsite, the Government will sample the material and will test the sample or will retain it in storage for possible future testing as considered appropriate.

1.5.3 Construction Testing by Government

The Government will sample and test aggregates and concrete to determine compliance with the specifications. The Contractor shall provide facilities and labor as necessary for procurement of representative test samples. Samples of aggregates will be obtained at the point of batching. Concrete will be sampled in accordance with ASTM C 172. Slump and air content will be determined in accordance with ASTM C 143 and ASTM C 231, respectively. Test specimens for strength determinations will be cured as described in ASTM C 31, and flexural strength determinations will be made by the third-point loading method presented in ASTM C 78.

1.6 MATERIAL DELIVERY, STORAGE, AND HANDLING

1.6.1 Cementitious Materials

1.6.1.1 Transportation

When bulk cement [or pozzolan] is not unloaded from primary carriers directly into weathertight hoppers at the batching plant, transportation from the railhead, mill, or intermediate storage to the batching plant shall be accomplished in adequately designed weathertight trucks, conveyors, or other means that will protect the cement [or pozzolan] completely from exposure to moisture.

1.6.1.2 Storage

Immediately upon receipt at the site of the work, cementitious materials shall be stored in a dry, weathertight, and properly ventilated structure. All storage facilities shall be subject to approval and shall permit easy access for inspection and identification. Sufficient cementitious materials shall be in storage to sustain continuous operation of the concrete mixing plant while pavement is being placed. To prevent cement from becoming unduly aged after delivery, the Contractor shall use any cement that has been stored at the site for 60 days or more before using cement of lesser age.

1.6.1.3 Separation of Materials

Separate facilities shall be provided for unloading, transporting, storing, and handling each type of cementitious material.

1.6.2 Aggregates

1.6.2.1 Storage

Aggregate shall be stored at the site of the batching plant in a manner to avoid breakage, segregation, or contamination by foreign materials. Each size of aggregate from each source shall be stored separately in free-draining stockpiles. Fine aggregate and the smaller sizes of coarse

aggregate shall remain in free-draining storage for at least 24 hours immediately prior to use. Sufficient aggregate shall be maintained at the site at all times to permit continuous uninterrupted operation of the mixing plant while concrete is being placed.

1.6.2.2 Handling

Aggregate shall be handled in a manner to prevent segregation. Vehicles used for stockpiling or moving aggregate shall be kept clean of foreign materials. Stockpiles shall be worked in a manner to prevent different sizes of aggregate from being mixed during storage or loading of batching hoppers.

1.7 APPROVAL OF PLANT, EQUIPMENT, AND CONSTRUCTION METHODS

1.7.1 Plant and Equipment

The Contracting Officer shall be given access at all times to all parts of the plant and equipment for checking adequacy of the equipment in use and operation of the plant, and for verifying weights, proportions, temperature, mixing time, and character of the materials.

1.7.1.1 Batch Plant

Details and data on the concrete plant shall be submitted for review.

1.7.1.2 Concrete Mixers

The make, type, capacity, and number of the concrete mixers proposed for use shall be submitted for review.

1.7.2 Construction Methods

1.7.2.1 Hauling Equipment

A description of the equipment proposed for transporting concrete from the central mixing plant to the placing equipment shall be submitted for review.

1.7.2.2 Placing Equipment

A description of the equipment proposed for placing concrete and the method of placing shall be submitted for review.

1.7.2.3 Finishing Equipment

A description of the equipment proposed for surface texturing and the method of surface texturing shall be submitted for review.

1.7.2.4 Curing Media

The curing media and methods to be used shall be submitted in writing for approval. The Contractor shall notify the Contracting Officer of the source from which the curing compound is to be obtained at least 60 days in advance of the time concrete placing is expected to begin. A manufacturer's certificate shall be furnished by the Contractor certifying that the impervious sheet curing materials, if used, comply with the requirements of ASTM C 171.

1.7.2.5 Cold Weather Requirements

When concrete is to be placed under or exposed to cold weather conditions, a description of the materials and methods proposed for protection of the concrete shall be furnished to the Contracting Officer for approval.

1.7.2.6 Hot Weather Requirements

When concrete is to be placed under or exposed to hot weather conditions, a description of the methods proposed for cooling aggregate and water and the methods used to prevent evaporation in excess of 0.2 psf per hour from the placed concrete shall be submitted to the Contracting Officer for approval.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Cementitious Materials

2.1.1.1 General Requirements

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NOTE: See Additional Notes G and H.

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Cementitious materials may be portland cement, portland blast-furnace slag cement, portland-pozzolan cement, or portland cement in combination with pozzolan or ground granulated blast-furnace slag as specified hereinafter.

2.1.1.2 Portland Cement

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NOTE: See Additional Note I.

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Portland cement shall conform to ASTM C 150, Type [I or II] [II] [V] [, low alkali] [, including a false-set requirement].

2.1.1.3 High Early-Strength Portland Cement

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NOTE: For moderate sulfate exposure, a limit of eight percent tricalcium aluminate should be specified. For severe sulfate exposure, a limit of five percent tricalcium aluminate should be specified. If alkali-reactive aggregates are a problem to the local area, "low-alkali" should be specified.

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High early-strength portland cement shall conform to ASTM C 150, Type III, [with tricalcium aluminate limited to [5] [8] percent,] [low-alkali,] and shall be used only when approved by the Contracting Officer.

2.1.1.4 Portland Blast-Furnace Slag Cement

Portland blast-furnace slag cement shall conform to ASTM C 595, Type IS [MS] [with mortar-bar expansion optional requirements].

2.1.1.5 Slag Cement

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NOTE: Slag cement is moderate sulfate-resistant but shall not be used where pavement is subject to severe sulfate exposure. If alkali-reactive aggregates are a problem to the local area, "with mortar-bar expansion optional requirements" should be included.

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Slag cement shall conform to the requirements of ASTM C 595, Type S [with mortar-bar expansion optional requirements].

2.1.1.6 Portland-Pozzolan Cement

Portland-pozzolan cement shall conform to the requirements of ASTM C 595, Type IP [MS] [with mortar-bar expansion optional requirements].

2.1.1.7 Pozzolan, General Requirements

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NOTE: Class N and Class C should be specified if available locally.

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Pozzolan shall conform to the requirements of ASTM C 618.

2.1.1.8 Pozzolan-Modified Portland Cement

Pozzolan-modified portland cement shall conform to the requirements of ASTM C 595, Type I (PM) [MS] [with mortar-bar expansion optional requirements].

2.1.1.9 Slag-Modified Portland Cement

Slag-modified portland cement shall conform to ASTM C 595, Type I (SM) [MS] [with mortar-bar expansion optional requirements].

2.1.1.10 Ground Granulated Blast-Furnace Slag

Ground granulated blast-furnace slag shall conform to ASTM C 989, Grade 100 or 120.

2.1.1.11 Transportation and Storage

Cementitious materials may be furnished in bulk or packages. When cementitious materials are furnished in packages, mixing batch proportions shall be adjusted to require use of complete packages of cement.

2.1.1.12 Temperature

The temperature of the cement [and pozzolan] as delivered to storage at the site, shall not exceed 150 degrees F.

2.1.2 Admixtures

2.1.2.1 Air-Entraining Admixtures

The air-entraining admixture shall conform to ASTM C 260 and shall consistently entrain the air content in the specified ranges under field conditions. The air-entraining admixture shall be in a solution of suitable viscosity for field use.

2.1.2.2 Accelerator

Calcium chloride shall conform to ASTM D 98. When approved or directed, the Contractor shall use not more than 1 percent of calcium chloride, by weight, of the cement. It shall be measured accurately and shall be added to the batch in solution in a portion of the mixing water. The use of calcium chloride in concrete shall in no way relieve the Contractor of responsibility for compliance with the requirements of these specifications governing protection and curing of concrete.

2.1.2.3 Retarder

A retarding admixture shall meet the requirements of ASTM C 494, Type B, except that the 6-month and 1-year compressive strength tests are waived. The use of the admixture is at the option of the Contractor.

2.1.2.4 Water-Reducer

A water-reducing admixture shall meet the requirements of ASTM C 494, Type A [or D] except that the 6-month and 1-year compressive strength tests are waived. The admixture will be added to the concrete mixture only when its use is approved or directed.

2.1.3 Curing Materials

2.1.3.1 Impervious Sheet

Impervious sheet materials shall conform to ASTM C 171, type optional, except polyethylene film, if used, shall be white opaque.

2.1.3.2 Curing Compounds

Membrane-forming curing compounds shall be white pigmented compounds conforming to COE CRD-C 300.

2.1.4 Dowels

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NOTE: If only a thin bonded rigid overlay is to be used, this paragraph will be deleted.

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Dowels shall be fabricated or cut to length at the shop or mill before delivery to the site. Dowels shall be free of loose flaky rust and loose scale and shall be clean and straight. Dowels shall be sheared to length provided that the deformation from true shape caused by shearing does not exceed 0.04 inch on the diameter of the dowel and does not extend more than 0.04 inch from the end of the dowel. Dowels shall be plain steel bars conforming to ASTM A 615, grade 40 or 60; ASTM A 616, grade 50 or 60; or ASTM A 617, grade 40 or 60; or shall be steel pipe conforming to ASTM A 53, extra strong, as indicated. Split dowels shall be of the threaded type, of approved design. The external and internal threaded portion of the split dowels shall conform to the thread designation given in the tabulation below. When 3-piece split dowels are furnished, the minimum coupling length shall be as indicated below:

Dowel Diameter Inches	Thread Designation	Minimum Coupling Length, Inches
3/4	7/8 - 9 - UNC - 2A-RH	2
1	1-1/8 - 7 - UNC - 2A-RH	2-1/2
1-1/4	1-3/8 - 6 - UNC - 2A-RH	3
1-1/2	1-3/4 - 5 - UNC - 2A-RH	3-3/4
2	2-1/4 - 4-1/2 - UNC - 2A-RH	4-3/4
3	3-1/4 - 4 - UNC - 2A-RH	6-3/4

The minimum length of each external threaded portion of the split dowels shall not be less than the nominal diameter of the dowel. Split dowels when assembled in place shall be straight, with length as specified, and shall have all external threads enclosed. End faces of couplings and of female portions of split dowels shall be squared to assure proper alignment of the dowel during installation.

2.1.5 Joint Filler

2.1.5.1 Filler for Expansion Joints

Filler shall be preformed materials conforming to ASTM D 1751 or ASTM D 1752.

2.1.5.2 Filler for Contraction Joints

Contraction joint filler shall be inserts conforming to COE CRD-C 572, ASTM D 2628, or ASTM D 2828.

2.1.6 Reinforcement

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NOTE: If only a thin bonded rigid overlay is to be used, the following paragraphs will be deleted.

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All reinforcement shall be free from loose flaky rust, loose scale, oil, grease, mud, or other coatings that might reduce the bond with concrete. Removal of thin powdery rust and tight rust is not required. However, reinforcing steel which is rusted to the extent that it does not conform to the required dimensions or mechanical properties shall not be used.

2.1.6.1 Bar Mats

Bar mats shall conform to ASTM A 184.

2.1.6.2 Wire Fabric

Welded steel wire fabric shall conform to ASTM A 185.

2.1.6.3 Deformed Wire Fabric

Welded deformed steel wire fabric shall conform to ASTM A 497.

2.1.6.4 Steel Fiber Reinforcing

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NOTE: If steel fiber reinforced concrete is to be used, this paragraph will be included.

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The steel fiber shall be formed by either cutting from wire or shearing from sheets. Minimum ultimate tensile strength shall be 50,000 psi. The maximum aspect ratio (length divided by diameter) shall not exceed 100. Fibers longer than 2-1/2 inches shall not be used without approval of the Contracting Officer. The fibers will be either straight or deformed. The fibers shall be clean and free of rust, oil, and deleterious materials.

2.1.7 Tie Bars

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NOTE: If only a thin bonded rigid overlay is to be used, this paragraph will be deleted.

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Tie bars shall be deformed steel bars conforming to ASTM A 615, ASTM A 616, or ASTM A 617, and of the sizes and dimensions indicated. Deformed rail steel bars and high-strength billet or axle steel bars, grade 60 or higher, shall not be used for bars that are bent and straightened during construction.

2.1.8 Epoxy-Resin

All epoxy-resin materials shall be two-component materials conforming to the requirements of ASTM C 881, class as appropriate for each application temperature to be encountered, and in addition, shall meet the following requirements:

2.1.8.1 Absorption

All materials shall have a 24-hour absorption not greater than 1 percent.

2.1.8.2 Bonding

The materials for bonding freshly mixed portland cement concrete or mortar or freshly mixed epoxy resin concrete or mortar to hardened concrete shall be Type II materials, grade as approved.

2.1.8.3 Patching

The materials for use as patching materials for complete filling of spalls, wide cracks, and other voids; for use for embedding dowels and anchor bolts; and for use as a binder in preparing epoxy resin mortars and concretes shall be Type III materials and shall in addition meet these requirements: (a) the bond strength at 14 days (moist cure) shall be at least 1000 psi, and (b) the volatile content, cured system, shall not exceed 3 percent. Grade shall be as approved except that Grade 3 shall be used for embedding dowels in hardened concrete.

2.1.9 Water

Water for washing aggregates and for mixing and curing concrete shall be fresh and free from injurious amounts of oil, acid, salt, alkali, organic matter, or other deleterious substances and shall comply with COE CRD-C 400.

2.1.10 Coarse Aggregate

2.1.10.1 Composition

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NOTE: See Additional Note J.

****

Coarse aggregate shall consist of [crushed] [uncrushed] gravel, [crushed] [uncrushed] stone, [crushed] [uncrushed] adequately seasoned blast-furnace slag, [reclaimed portland cement concrete] or a combination thereof. [Crushed gravel shall contain not less than 60 percent of crushed particles by weight.]

[Aggregate used for paving the calibration hardstand shall be free of materials having magnetic properties.]

2.1.10.2 Quality

Aggregates as delivered to the mixers shall consist of clean, hard, uncoated particles meeting the requirements of ASTM C 33. Dust and other coating shall be removed from the coarse aggregates by washing. Blast-furnace slag conforming to the grading to be used in the concrete shall have a compact weight of not less than 70 pcf determined in accordance with ASTM C 29.

2.1.10.3 Particle Shape

Particles of the coarse aggregate shall be generally spherical or cubical in shape. The quantity of flat and elongated particles in any size group shall not exceed 20 percent by weight as determined by COE CRD-C 119. A flat

particle is defined as one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3.

2.1.10.4 Size and Grading

****

NOTE: If only a thin bonded rigid overlay is to be used, edit this paragraph appropriately.

****

The nominal maximum size of the coarse aggregate shall be [_____] inches. When the nominal maximum size is greater than 1 inch, the aggregates shall be furnished in two size groups as follows:

Maximum Nominal Size Inches	Size Group
1-1/2	No. 4 to 3/4 inch 3/4 inch to 1-1/2 inches
2	No. 4 to 1 inch 1 inch to 2 inches

The grading of the coarse aggregate within the separated size groups shall conform to the requirements of ASTM C 33, Sizes 67, 57, 4 and 3 as delivered to the mixer.

[The nominal maximum size aggregate used in a thin bonded overlay shall not exceed one-third of the overlay thickness. Overlay thickness used in determining coarse aggregate size shall not include additional thickness for leveling. The entrained air content shall be increased nearer the upper limit as the maximum coarse-aggregate size is decreased.]

2.1.10.5 Deleterious Substances

****

See Additional Note K.

****

The amount of deleterious substances in each size group of coarse aggregate shall not exceed the limits shown below, determined in accordance with ASTM C 117, ASTM C 123, ASTM C 142, and ASTM C 295, applicable only to material coarser than 3/8 inch.

LIMITS OF DELETERIOUS SUBSTANCES IN COARSE AGGREGATE FOR AIRFIELD PAVEMENTS
(Percentage by Weight)

	Areas with	Areas with	Areas with	Areas with

Materials	Major Popouts Severe Weather	Major Popouts Moderate Weather	Minor Popouts Severe Weather	Minor Popouts Moderate Weather
Clay lumps	0.2	0.2	2.0	2.0
Shale(1)	0.1	0.2	1.0	1.0
Material finer than No. 200 sieve(2)	0.5	0.5	1.0	1.0
Lightweight particles(3)	0.2	0.2	0.5	0.5
Clay ironstone(4)	0.1	0.5	1.0	1.0
Chert and cherty stone (less than 2.40 specific gravity SSD)(5)	0.1	0.5	1.0	5.0
Claystone, mudstone, and siltstone(6)	0.1	0.1	1.0	1.0
Shaley and argillaceous limestone(7)	0.2	0.2	1.0	1.0
Other soft particles	1.0	1.0	1.0	2.0
Total of all deleterious substances exclusive of material finer than No. 200 sieve	1.0	2.0	3.0	5.0

(1) Shale is defined as a fine-grained thinly laminated or fissile sedimentary rock. It is commonly composed of clay or silt or both. It has been indurated by compaction or by cementation, but not so much as to have become slate.

(2) Limit for material finer than No. 200 sieve will be increased to 1.5 percent for crushed aggregates if the fine material consists of crusher dust that is essentially free from clay or shale.

(3) The separation medium shall have a specific gravity of 2.0. This limit does not apply to coarse aggregate manufactured from blast-furnace slag unless contamination is evident.

(4) Clay ironstone is defined as an impure variety of iron carbonate, iron oxide, hydrous iron oxide, or combinations thereof, commonly mixed with clay, silt, or sand. It commonly occurs as dull, earthy particles, homogeneous concretionary masses, or hard shell particles with soft interiors. Other names commonly used for clay ironstone are "chocolate bars" and limonite concretions.

(5) Chert is defined as a rock composed of quartz, chalcedony or opal, or any mixture of these forms of silica. It is variable in color. The texture is so fine that the individual mineral grains are too small to be distinguished by the unaided eye. Its hardness is such that it scratches glass but is not scratched by a knife blade. It may contain impurities such as clay, carbonates, iron oxides, and other minerals. Other names commonly applied to varieties of chert are: flint, jasper, agate, onyx, hornstone, porcellanite, novaculite, sard, carnelian, plasma, bloodstone, touchstone, chrysoprase, heliotrope, and petrified wood. Cherty stone is defined as any type of rock (generally limestone) that contains chert as lenses and

nodules, or irregular masses partially or completely replacing the original stone.

(6) Claystone mudstone, or siltstone is defined as a massive fine-grained sedimentary rock that consists predominantly of clay or silt without laminations or fissility. It is indurated either by compaction or by cementation.

(7) Shaley limestone is defined as a limestone in which shale occurs as one or more thin beds or laminae. These laminae may be regular or very irregular and may be spaced from a few inches down to minute fractions of an inch. Argillaceous limestone is defined as a limestone in which clay minerals occur disseminated in the stone in the amount of 10 to 50 percent by weight of the rock; when these make up from 50 to 90 percent, the rock is known as calcareous (or dolomitic) shale (or claystone, mudstone, or siltstone).

LIMITS OF DELETERIOUS SUBSTANCES IN COARSE AGGREGATE FOR ROAD PAVEMENTS
(* Percentage by Weight)

Clay lumps and friable particles	2.0
Material finer than No. 200 sieve	1.0
Lightweight particles	1.0
Other soft particles	2.0

* The total of all deleterious substances shall not exceed 5.0 percent of the weight of the aggregate. The percentage of material finer than No. 200 sieve shall not be included in this total. The limit for material finer than No. 200 sieve shall be increased to 1.5 percent for crushed aggregates consisting of crusher dust that is essentially free from clay or shale. The separation medium shall have a specific gravity of 2.0. This limit does not apply to coarse aggregate manufactured from blast-furnace slag unless contamination is evident.

2.1.11 Fine Aggregate

2.1.11.1 Composition

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NOTE: See Additional Note L.

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Fine aggregate shall consist of natural sand, manufactured sand, or a combination of the two, and shall be composed of clean, hard, durable particles.

[Aggregate used for paving the calibration hardstand shall be free of materials having magnetic properties.]

Fine aggregate shall consist of the minus 3/8-inch material from the reclaimed portland cement concrete or a combination of the crushed reclaimed concrete blended with sand. If insufficient fine aggregate is available

from the recycling process, the additional material shall be natural sand, manufactured sand or a combination thereof meeting all requirements specified. Irrespective of the source from which it is obtained, all fine aggregate shall be composed of clean, hard durable particles. Each type of fine aggregate shall be stockpiled and batched separately. Any degree of contamination will be cause for the rejection of the entire stockpile.

2.1.11.2 Particle Shape

Particles of the fine aggregate shall be generally spherical or cubical in shape.

2.1.11.3 Grading

Grading of the fine aggregate, as delivered to the mixer, shall conform to the requirements of ASTM C 33.

In addition, the fine aggregate, as delivered to the mixer, shall have a fineness modulus of not less than 2.40 nor more than 2.90. The grading of the fine aggregate also shall be controlled so that the fineness moduli of at least nine of ten samples of the fine aggregate, as delivered to the mixer, will not vary more than 0.15 from the average fineness moduli of all samples previously taken. The fineness modulus shall be determined by COE CRD-C 104.

2.1.11.4 Deleterious Substances

The amount of deleterious substances in the fine aggregate shall not exceed the following limits:

Material	Percentage by Weight
Clay lumps and friable particles	1.0
Material finer than No. 200 sieve	3.0
Lightweight particles	0.5

The total of all deleterious materials shall not exceed 3.0 percent of the weight of the aggregate.

2.1.12 Mortar Sand

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NOTE: If only a thin bonded rigid overlay is to be used, this paragraph will be used.

****

Mortar sand shall conform to ASTM C 144.

2.2 MIXTURE PROPORTIONING

2.2.1 Composition

Concrete shall be composed of cementitious material, water, fine and coarse aggregates, and admixtures. The cementitious materials shall be portland

cement [or portland blast-furnace slag cement] [or portland pozzolan cement] [or portland cement in combination with slag cement or pozzolan]. The admixture shall be an air-entraining admixture [or will be an air-entraining admixture plus either a retarding admixture, a water-reducing admixture, or an accelerator as approved or directed].

2.2.2 Control

The proportions of all material entering into the concrete will be furnished by the [Contractor] [Contracting Officer]. The proportions will be changed as necessary to maintain the workability, strength, and standard of quality required for the concrete covered by these specifications, and to meet the varying conditions encountered during the construction. The Contracting Officer shall be notified before any changes are made to the proportions of materials.

2.2.3 Cement Content

[The cement content of the concrete will range from an approximate minimum of [_____] to an approximate maximum of [_____] pounds per cubic yard. [When a pozzolan is used, the total absolute volume of cementitious material will be within the same range in absolute volume as specified above but shall not exceed 25 percent of the solid volume of portland cement plus pozzolan].] [The cement content of the concrete will be that necessary to meet the strength requirements specified. [When a pozzolan is used, the absolute volume of cementitious material will be the same as required for cement but shall not exceed 25 percent of the solid volume of portland cement plus pozzolan].]

2.2.4 Aggregate Content

The amount of each type aggregate used in the concrete mixture shall be as determined by the mixture proportioning studies.

2.2.5 Flexural Strength

****

NOTE: If steel fiber reinforced concrete is to be used, edit this paragraph appropriately.

****

Proportioning requirements for concrete shall be designed for a flexural strength of [_____] psi at [_____] day age when tested in accordance with ASTM C 78.

[Proportioning requirements for steel fiber reinforced concrete shall be designed for a flexural strength at maximum load of [_____] psi at [_____] day age when tested in accordance with the modulus of rupture test as specified in ACI 544.2R]

2.2.6 Air Content

The air content by volume based on measurements made immediately after discharge from the mixer shall be [_____] percent plus or minus 1-1/2 percent when determined in accordance with ASTM C 231 or with ASTM C 173 for concrete made with slag aggregates.

2.2.7 Slump

The concrete slump shall be between [_____] and [_____] inches when determined in accordance with ASTM C 143.

PART 3 EXECUTION

3.1 PRODUCTION OF CONCRETE

3.1.1 Location of Plant

The batching plant or central mixing plant shall be located on or off the Government premises as approved.

3.1.2 Capacity

Each concrete mixer shall have a capacity of not less than 5 cubic yards. Batching, mixing, and hauling equipment shall have a capacity sufficient to maintain a forward movement of the paver of not less than 2.5 fpm.

3.1.3 Batching Plant

The batching plant shall conform to the requirements of COE CRD-C 95and as specified; however, rating plates attached to batch plant equipment are not required.

3.1.3.1 Equipment Requirements

The batching controls shall be either semiautomatic or automatic. Semiautomatic batching system shall be provided with interlocks. Separate bins or compartments shall be provided for each size group of aggregate [and pozzolan] and cement. If both cement and pozzolan are used, they may be batched cumulatively provided portland cement is batched first. If measured by weight, water shall not be weighed cumulatively with another ingredient. Water batcher filling and discharging valves shall be so interlocked that the discharge valve shall not be opened before the filling valve is fully closed. An accurate mechanical device for measuring and dispensing each admixture shall be provided. Each dispenser shall be interlocked with the batching cycle and discharged automatically in a manner to obtain uniform distribution throughout the batch in the specified mixing period. [Where use of truck mixers makes this requirement impracticable, the admixture dispensers shall be interlocked with the sand batches.] Admixtures will not be combined before introduction in [sand or] water. The plant shall be arranged so as to facilitate the inspection of all operations at all times. Suitable facilities shall be provided for obtaining representative samples of aggregates from each bin or compartment.

3.1.3.2 Scales

Adequate facilities shall be provided for the accurate measurement and control of each of the materials entering each batch of concrete. The weighing equipment shall conform to the applicable requirements of NIST PB 90-184961, except that the accuracy shall be within 0.2 percent of scale capacity. The Contractor shall provide standard test weights and any other auxiliary equipment required for checking the operating performance of each scale or other measuring device. Each weighing unit shall include a visible springless dial, which shall indicate the scale load at all stages of the weighing operation or shall include a beam scale with a beam balance indicator that will show the scale in balance at zero load and at any beam setting. The indicator shall have an over and under travel equal to at

least 5 percent of the capacity of the beam. The weighing equipment shall be arranged so that the concrete plant operator can conveniently observe the dials or indicators.

3.1.3.3 Batching Tolerances

a. Weighing Tolerances: Whichever of the following tolerances is greater shall apply, based on required scale reading.

Materials	Percentage of Required Weight	Percentage of Scale Capacity
Cement (and Pozzolan)	plus or minus 1	plus or minus 0.3
Aggregate	plus or minus 2	plus or minus 0.3
Water	plus or minus 1	plus or minus 0.3
Admixture	plus or minus 3	plus or minus 0.3

b. Volumetric Tolerances: For volumetric batching equipment, the tolerances that shall apply to the required volume of material being batched are: (a) water - plus or minus 1 percent, and (b) admixtures - plus or minus 3 percent.

3.1.3.4 Moisture Control

The plant shall be capable of ready adjustment to compensate for the varying moisture contents of the aggregates and to change the weights of the materials being batched. [An electric moisture meter complying with the provisions of COE CRD-C 143 shall be provided for measuring of moisture in the fine aggregate. The sensing element shall be arranged so that measurement is made near the batcher charging gate of the sand bin or in the sand batcher.]

3.1.4 Concrete Mixers

3.1.4.1 General Requirements for Mixers

The mixers shall not be charged in excess of the capacity recommended by the manufacturer. The mixers shall be operated`at the drum or mixing blade speed designated on the manufacturer's data plate. The mixers shall be maintained in satisfactory operating condition, and the mixer drums shall be kept free of hardened concrete. When any mixer at any time produces unsatisfactory results, its use shall be promptly discontinued until it is repaired.

3.1.4.2 Central Plant Mixers

Central plant mixers shall be tilting, nontilting, or vertical-shaft type and shall be provided with an acceptable device to lock the discharge mechanism until the required mixing time has elapsed.

3.1.4.3 Mixing Time and Uniformity

For concrete plant mixers, in the absence of uniformity data, the mixing time for each batch after all solid materials are in the mixer, provided that all of the mixing water is introduced before one-fourth of the mixing time has elapsed, shall be 1 minute for mixers having a capacity of 1 cubic yard. For mixers of greater capacity, the minimum time shall be increased 15 seconds for each additional cubic yard or fraction thereof. These mixing times are predicated on operation at a designated speed and proper

introduction of materials into the mixer. The mixing time shall be reduced, if so approved, to the minimum time required to meet all the uniformity requirements. Mixer performance tests in accordance with COE CRD-C 55 at the proposed reduced mixing times shall be performed, and the mixer shall meet the following requirements when tested in accordance with the COE CRD-C 55 as required in the paragraph CONTRACTOR QUALITY CONTROL:

Test	Permissible Range of Results
Weight per cubic foot of mortar calculated to an air-free basis	1.0 lb/cu. ft.
Air content	1.0 percent (volume)
Slump	1.0 inch
Coarse aggregate content, portion by weight of each sample retained on No. 4 sieve	6.0 percent
Average compressive strength at 7 days for each sample based on average strength of all test specimens	10.0 percent
Water content, portion by weight of each sample passing No. 4 sieve	1.0 percent

3.1.4.4 Truck Mixers

Each truck shall be permanently marked with the volume of mixed concrete and the mixing and agitating speeds. Each truck shall be equipped with counters to determine the number of revolutions at mixing and agitating speeds. Concrete completely mixed in a truck mixer shall be mixed 70 to 100 revolutions at a designated mixing speed after all ingredients including mixing water have been charged into the drum. Concrete first partially intermingled in a concrete plant mixer (shrink-mixed) a minimum time as required to combine the ingredients shall then be completely mixed in a truck mixer. The number of revolutions between 70 to 100 for truck-mixed concrete and the number of revolutions for shrink-mixed concrete shall be determined by uniformity tests as specified in requirements for mixer performance stated in paragraph CONTRACTOR QUALITY CONTROL. If requirements for the uniformity of concrete are not met with 100 revolutions of mixing after all ingredients including water are in the drum, the mixer shall not be used until the condition is corrected. Additional revolutions beyond the number determined to produce the required uniformity shall be at a designated agitating speed. Water shall not be added after the initial introduction of mixing water, except when on arrival at the jobsite the slump is less than specified and the water-cement ratio is less than the approved mixture design permits. Additional water will be added to bring the slump within the specified range provided the approved water-cement ratio is not exceeded. Water shall be injected into the mixer under pressure, and the drum or blades shall be turned a minimum of 30 additional revolutions at mixing speed. Water shall not be added to the batch at any later time.

3.1.5 Mixing Fiber Reinforced Concrete

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NOTE: If steel fiber reinforced concrete is to be used, this paragraph will be included.

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Fibers shall be added as specified in ACI 544.3R. The method of addition shall ensure that the fibers do not pile up or form clumps.

3.2 TRANSPORTING EQUIPMENT

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NOTE: For vehicular parking areas and paving projects of 1600 cubic yards or less, the text in the second set of brackets may be used.

****

Transportation of concrete mixed completely in a stationary mixer from the mixer to the point of placement shall be by truck agitator, in a truck mixer operating at agitator speed, or in nonagitating equipment. All transporting equipment shall conform to ASTM C 94, except as modified herein. Vehicles transporting concrete mixed partially or completely in stationary mixers and truck mixers used for complete concrete mixing shall be capable of delivering and discharging the concrete without segregation. Equipment shall be provided that is capable of transferring the concrete from the transporting vehicle and distributing the concrete without segregation into its final position. [The transfer and distribution of the concrete shall be by a mechanical spreader or by a concrete bucket and crane.] [Placement shall be made alternately from both sides of the paving lane with chutes capable of delivering uniformly freshly mixed concrete to the middle of the paving lane. Any concrete having a slump greater than 2 inches shall be removed from the job. When, upon trial, an unsatisfactory or segregated mixture is deposited, equipment shall be provided capable of transferring and distributing concrete without segregation into its final position in the form.] When the stabilized subgrade or base course is of sufficient strength to support concrete transportation equipment without rutting or deformation, concrete may be discharged in front of the paver. The surface on which the pavement is being placed shall be maintained free from foreign materials or concrete that has begun to harden.

3.3 PLACING

3.3.1 General Placing Requirements

Concrete [shall be placed between stationary forms] [may be constructed to the desired cross section using slipform pavers]. Concrete shall be deposited between the forms or placed with the slipform paver within 45 minutes from the time cement has been charged into the mixing drum. Concrete shall be deposited as close as possible to its final position in the pavement cross section. The placement of the concrete shall be continuous and at a uniform rate without unscheduled stops except for equipment failure or other emergencies. Workmen with foreign material on their footwear or construction equipment that might deposit foreign material

shall not be permitted to walk or to operate in the concrete during placement and finishing operations.

3.3.2 Slipform Method

The slipform paver shall be self-propelled, automatically controlled, crawler-mounted, and capable of spreading, consolidating, and shaping the plastic concrete to the desired cross section in one pass. The paver shall be capable of finishing the surface and edges so that a minimum amount of hand finishing is required, and shall have sufficient weight and power to handle the amount of concrete required for the full-lane width as specified. The mechanisms for forming the pavement shall be easily adjustable in width and thickness. Horizontal alignment shall be referenced to a taut wire or string line. Vertical alignment shall be referenced to a taut wire or string line, to the surface of the underlying material, or to the surface of previously constructed pavement. The vibrators or tamping elements shall be automatically controlled so that they shall be stopped as forward motion ceases. When the paver approaches a header at the end of a paving lane, a sufficient amount of concrete shall be maintained ahead of the paver to allow a roll of concrete to spill over the header. The amount of extra concrete shall be sufficient to prevent the slurry that is formed and carried along ahead of the paver from being deposited adjacent to the header. The spud vibrators on the front of the paver shall be brought as close to the header as possible before they are lifted. Additional consolidation shall be provided adjacent to the headers by hand-manipulated vibrators. When the slipform paver is operated between or adjacent to previously constructed pavement, provisions shall be made to prevent damage to the previously constructed pavement. Transversely oscillating screeds shall be electronically controlled from the previously placed pavement to prevent the screed from applying pressure to the existing pavement. When the paver travels on existing pavement, provisions shall be made to prevent damage to the existing pavement. Slipform pavers using transversely oscillating screeds shall not be used to form fill-in lanes that have widths less than a full width for which the paver was designed.

3.3.3 Spreading

Spreading shall be by machine method, except when transporting equipment is permitted on the underlying material, in which case the concrete may be discharged directly in front of the paver. When placed directly in front of the paver, the concrete shall be spread evenly across the full width of the paving lane. Hand spreading will be permitted only where required for odd widths or shapes of slabs. Hand spreading shall be done with shovels; rakes shall not be used. Mechanical spreaders shall be designed and operated to distribute the plastic concrete uniformly across the full width of the paving lane. Machines that cause displacement of properly installed forms or ruts or indentations in the prepared underlying material and machines that cause frequent delays due to mechanical failures shall be replaced as directed. When the spreader rides the edges of previously constructed lanes, provisions shall be made to prevent damage to the previously constructed pavement. Where concrete is delivered to the form in truck mixers, suitable chutes will be used, provided windrows cover essentially the entire area within the form. In no case is the dumping of concrete at one location and the running into place with vibration permitted. The spreading of concrete shall be performed at such elevations, slightly above grades, that when properly consolidated, the surface will be at the elevation indicated.

3.3.4 Vibration

Concrete shall be consolidated with mechanical vibrating equipment immediately after spreading. Vibrating equipment shall be of the internal type, and the number of units and the power of each unit shall be adequate to properly consolidate the concrete with the vibration spacing used. The vibrating unit shall be mounted on a frame or on the paver and equipped with suitable controls so that all vibrators may be operated at any desired depth within the slab or completely withdrawn from the concrete, as required. The spacing of vibrating units that extend into the slab at intervals across the paving lane shall be as necessary to properly consolidate the concrete, but the clear distance between the units shall not exceed 30 inches. The outside elements of the internal spud vibrator units shall be approximately 1 foot from the edge of the slab. Vibrators of this type shall be inserted into the concrete to a depth that will provide the best consolidation but not closer to the underlying material than 2 inches. Concrete in odd-shaped slabs or in locations inaccessible to the vibrating equipment above shall be vibrated with a hand-manipulated vibrator. Vibrators shall not be used to transport or spread the concrete in the forms. Spud vibrators shall operate at a frequency of not less than 8000 impulses per minute and tube vibrators at a frequency of not less than 5000 impulses per minute when in the concrete. Excessive vibration will not be permitted. Vibrators shall not be operated in the concrete at one location for more than 20 seconds. Forward motion of the paver shall cease as soon as a vibrator becomes inoperable and shall not start until the vibrator is repaired or replaced. At least one additional vibrator, or sufficient parts for replacing and repairing vibrators or vibrator assemblies for each paving train, shall be maintained at the site at all times.

3.3.5 Placing Reinforcing Steel

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NOTE: If only a thin bonded rigid overlay is to be used, this paragraph will be deleted.

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The type and amount of steel reinforcement shall be as shown on the contract drawings. For pavement thickness of 12 inches or more, the reinforcement steel shall be installed by the strike-off method wherein the concrete is deposited on the underlying material, consolidated, and struck to the indicated elevation of the steel reinforcement. The reinforcement shall be laid upon the prestruck surface, and the remaining concrete shall then be placed and finished in the required manner. When placement of the second lift causes the steel to be displaced horizontally from its original position, provisions shall be made for increasing the thickness of the first lift and depressing the reinforcement into the plastic concrete to the required elevation. The increase in thickness shall be only as necessary to permit the correct horizontal alignment to be maintained. Any portions of the bottom layer of concrete that have been placed more than 30 minutes without being covered with the top layer shall be removed and replaced with newly mixed concrete without additional cost to the Government. For pavements less than 12-inches thick, bar mat reinforcement shall be positioned on suitable chairs before concrete placement. Wire fabric and deformed wire fabric reinforcement shall be pushed down to its correct position by suitable vibratory equipment after the full depth of concrete, less than 12-inches thick, has been placed. Regardless of the placement procedure, the reinforcing steel shall be free from coatings that could

impair bond between the steel and the concrete, and laps in the reinforcement shall be as indicated.

3.3.6 Placing During Cold Weather

Concrete placement shall be discontinued when the air temperature reaches 40 degrees F and is falling. Placement may begin when the air temperature reaches 35 degrees F and is rising. Provision shall be made to protect the concrete from freezing during the specified curing period. If necessary to place concrete when the temperature of the air, aggregates, or water is below 35 degrees F, placement shall be approved in writing. Approval shall be contingent upon conformance with the following provisions. The underlying material shall be prepared and protected so that it is entirely free of frost when the concrete is deposited. Mixing water and/or aggregates shall be heated as necessary to result in the temperature of the in-place concrete being between 50 and 85 degrees F. Methods and equipment for heating shall be approved. The aggregates shall be free of ice, snow, and frozen lumps before entering the mixer. Covering and other means shall be provided for maintaining the concrete at a temperature of at least 50 degrees F for not less than 72 hours after placing, and at a temperature above freezing for the remainder of the curing period. Concrete damaged by freezing shall be removed and replaced as specified in paragraph REMOVAL AND REPLACEMENT OF DEFECTIVE CONCRETE.

3.3.7 Placing During Hot Weather

During periods of hot weather when the maximum daily air temperature is likely to exceed 85 degrees F, the following precautions shall be taken. The forms and the underlying material shall be sprinkled with water immediately before placing the concrete. Concrete shall be placed at the coolest temperature practicable, and in no case shall the temperature of the concrete when placed exceed 90 degrees F. Aggregates and/or mixing water shall be cooled as necessary. Concrete shall be placed continuously and rapidly at a rate of not less than 100 feet of paving lane per hour. The finished surfaces of the newly laid pavement shall be kept damp by applying a waterfog or mist with approved spraying equipment until the pavement is covered by the curing medium. If necessary, wind screens shall be provided to protect the concrete from an evaporation rate in excess of 0.2 psf per hour.

3.3.8 Thin Bond Rigid Overlay

3.3.8.1 Preparation of Existing Surfaces

Preparation of Existing Surfaces: In the areas to receive overlays, mechanical rotary abraders, cold milling equipment, or other equivalent equipment approved by the Contracting Officer shall be used to remove the entire surface of the existing concrete to a depth of not less than 1/4 inch and to such additional depth where necessary to expose a surface of sound, unweathered concrete that is uncontaminated by oils, greases or deicing salts or solutions. After removing existing concrete the surface shall be cleaned by air, water, sand, or shot blasting techniques to remove debris left from grinding. The surface shall then be thoroughly cleaned by brooming and blowing with compressed air. Acid treatment is not required for surface preparation.

3.3.8.2 Preparation of Joints

Joint-sealing and expansion joint materials shall be removed flush with the prepared surface, and, if found on the surface to receive the overlay, shall

be removed by sandblasting. The use of solvents shall not be permitted. Care shall be used to prevent bonding of the adjacent concrete overlays at the existing longitudinal construction joints. Maintenance of these existing joints shall be accomplished with fiberboard filler or other approved inserts of appropriate dimensions.

3.3.9 Bonded Overlay Methods

Fully Bonded Overlays shall be placed by either the EPOXY RESIN GROUT bonding method or the PORTLAND CEMENT MORTAR bonding method specified below. Trucks delivering concrete to the work site shall be operated to ensure that they do not contaminant the prepared surfaces with dirt, oil, or other debris.

3.3.9.1 Epoxy-Resin Grout Bonding Course

Prior to placing the concrete overlay, the previously prepared surfaces shall be washed with a high-pressure water jet followed by an air jet to remove free water. The clean surface shall then be coated with a 20 to 40 mil thick film of the epoxy-resin grout. The epoxy-resin grout shall be placed in one application, just prior to concrete placement, with the use of mechanical combination mixing and spraying equipment, or shall be applied in two coats with stiff brushes. The first brush coat shall be scrubbed into the concrete surface, followed by an additional brush coat to obtain the required thickness. When the brush method is used, the initial coat will be allowed to dry; however, the final coat shall be applied just prior to placement of concrete.

a. Epoxy-resin grout components shall be mixed in the proportions recommended by the manufacturer. The components shall be kept at 70 degrees F to 85 degrees F for 48 hours prior to mixing. The two epoxy components shall be mixed with a power-driven explosion proof stirring device in a metal or polyethylene container having a hemispherical bottom for the mixing vessel. The polysulfide-curing-agent component shall be added gradually to the epoxy-resin component with constant stirring until a uniform mixture is obtained. The rate of stirring shall be such that entrained air is minimized.

b. Tools and equipment used further in the work shall be thoroughly cleaned before the epoxy-resin grout sets.

c. Time Placement for Concrete Overlay: The placement of the concrete shall be completed while the epoxy-resin grout is still tacky. The epoxy resin grout shall be placed 6 to 10 feet ahead of concrete placing.

3.3.9.2 Portland Cement-Mortar Bonding Course

Immediately prior to placing concrete overlay, a mortar bonding course shall be applied to the prepared surface. The prepared surface will be moist but shall be without free water when the bonding course is applied. The mortar shall consist of equal parts of portland cement and sand by weight and not more than 6 gallons of water per bag of cement. Mortar shall be thoroughly mixed to a thick creamy mixture in a mechanical mixer. The mortar shall be spread over the surface with a stiff broom to an overall thickness of 1/16 inch. Particular care shall be taken to obtain complete coverage of the surface along joints, edges, and in corners.

The bonding course shall be covered with concrete before the mortar has taken its initial set but not longer than 30 minutes after it is mixed.

3.3.9.3 Health and Safety Precautions

a. Full face shields shall be provided for personnel during mixing and blending operations and during placing operations as required.

b. Protective coveralls and neoprene-coated gloves shall be provided all workmen engaged in the operation.

c. Protective creams of a suitable nature for the operation shall be supplied.

d. Adequate fire protection shall be maintained at all mixing and placing operations.

e. Smoking or the use of spark or flame producing devices shall be prohibited within 50 feet of mixing and placing operations.

f. The mixing, placing, or storage of epoxy-resin grout or solvent shall be prohibited within 50 feet of any vehicle, equipment, aircraft, or machinery that could be damaged from fire or could ignite vapors from the material.

3.4 FINISHING

Finishing operations shall be started immediately after placement of the concrete. Finishing shall be by the machine method except where otherwise indicated; the hand method will be permitted on odd slab widths or shapes and in event of breakdown of the mechanical equipment, to finish concrete. The sequence of operations shall be finishing, floating, straightedging, texturing, and then edging of joints. Finishing equipment and tools shall be maintained clean and in an approved condition.

3.4.1 Machine Finishing with Fixed Forms

3.4.1.1 Equipment

The finishing machines shall be of ample weight and power for proper finishing of the concrete. The finishing machine shall be designed and operated to strike off, screed, and consolidate the concrete. Screed and float adjustments of these machines shall be checked at the start of each day's paving operations and more often as required. Machines that cause displacement of side forms or that cause frequent delays due to mechanical failure shall be replaced. When finishing machines ride the edge of a previously constructed slab, provision shall be made to protect the surface of these slabs.

3.4.1.2 Transverse Finishing

As soon as placed, the concrete shall be accurately struck off and screeded to the crown and cross section shown and to such elevation that when consolidated and finished, the surface of the pavement will be free from porous places and will be at the required grade. The finishing machine shall make as many trips over each area of pavement as necessary to compact the concrete and produce a surface of uniform texture. Water shall not be added to the concrete used to fill low spots or to facilitate finishing operations. Excessive manipulation that brings mortar and water in excess of 1/8-inch thick to the surface will not be permitted, and any equipment that does not produce the required compaction and surface finish without an excessive number of trips will be considered unsatisfactory. The top of the

form or pavement edge upon which the finishing machine travels shall be kept clean.

3.4.1.3 Mechanical Floating

After completion of screeding, the mechanical float shall be operated to smooth and finish the pavement to grade. The float shall be operated to maintain contact with the surface at all times. If required, additional concrete shall be placed and screeded, and the float operated over the same area until a satisfactory surface is produced.

3.4.1.4 Other Types of Finishing Equipment

Concrete finishing equipment of types other than specified above may be used on a trial basis. The use of equipment that fails to produce finished concrete of the quality and consistency required by these specifications shall be discontinued, and the concrete shall be finished with approved equipment and in the manner specified above.

3.4.2 Finishing by Slipform Method

The slipform paver shall be capable of finishing the surface and edges so that only a minimum of additional work is necessary. A self-propelled pipe float may be used if the Contractor desires, while the concrete is still plastic, to remove minor irregularities and score marks. Straightedge finishing will be used as required; however, its use shall be kept to a minimum. The pipe float shall be 6 to 10 inches in diameter and sufficiently long to span the full paving width when oriented at an angle of approximately 60 degrees with the center line. Pipe floating will be accomplished as soon as possible and discontinued immediately after a uniform surface appearance is achieved. Concrete slurry permitted to run down the vertical edges of the slipped concrete will be removed by hand, using stiff brushes or other approved scrapers. Concrete slurry will not be used to build up along the edges of the concrete to compensate for excessive edge slump. Wood or metal forms shall be available for use in repairing edges that slough excessively. In locations where excessive sloughing occurs, the wood or metal forms shall be securely attached to the underlying material in the proper location, and the defective edges corrected to the permissible tolerances. These procedures are to be used sparingly, and when excessive sloughing occurs, operations shall be halted until proper corrective adjustments have been made. Such procedures are not to be considered as routine corrective measures for edge instability.

3.4.3 Hand Finishing

3.4.3.1 Equipment

A strike and tamping template and a longitudinal float shall be provided for hand finishing. The template shall be at least 1 foot longer than the width of pavement being finished, of an approved design, and sufficiently rigid to retain its shape, and shall be constructed of metal or other suitable material shod with metal. The longitudinal float shall be at least 10 feet long, of approved design, and rigid and substantially braced, and shall maintain a plane surface on the bottom of the base.

3.4.3.2 Finishing and Floating

As soon as placed and vibrated, the concrete shall be struck off and screeded to the crown and cross section and to such elevation above grade that when consolidated and finished, the surface of the pavement will be at

the required elevation. The entire surface shall be tamped, and the tamping operation continued until the required compaction and reduction of internal and surface voids are accomplished. Immediately following the final tamping of the surface, the pavement shall be floated longitudinally from bridges resting on the side forms and spanning but not touching the concrete. If necessary, additional concrete shall be placed and screeded, and the float operated until a satisfactory surface has been produced. The floating operation shall be advanced not more than half the length of the float and then continued over the new and previously floated surfaces.

3.4.4 Surface Correction and Testing

After finishing is completed but while the concrete is still plastic, minor irregularities and score marks in the pavement surface shall be eliminated by means of straightedges. Straightedges shall be 12 feet in length and shall be operated from the sides of the pavement and from bridges. A straightedge operated from the side of the pavement shall be equipped with a handle 3 feet longer than one-half the width of the pavement. The surface shall then be tested for trueness with a 12-foot straightedge held in successive positions parallel and at right angles to the center line of the pavement, and the whole area covered as necessary to detect variations. The straightedge shall be advanced along the pavement in successive stages of not more than one-half the length of the straightedge. Depressions shall be immediately filled with freshly mixed concrete, struck off, consolidated, and refinished. Projections above the required elevation shall also be struck off and refinished. The straightedge testing and finishing shall continue until the entire surface of the concrete is free from observable departure from the straightedge and conforms to the surface requirements specified in paragraph PAVEMENT QUALITY CONTROL.

3.4.5 Texturing

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See Additional Note M.

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Before the surface sheen has disappeared and before the concrete becomes nonplastic, the surface of the pavement shall be given a texture as follows:

3.4.5.1 Burlap-Drag Texture

[Surface texture shall be applied by dragging the surface of the pavement, in the direction of the concrete placement, with an approved multiple-ply burlap drag at least 3 feet in width and equal in length to the width of slab. The leading shall be cleaned and changed as required. The dragging shall produce a uniform finished surface having a fine sandy texture without disfiguring marks.]

3.4.5.2 Wire Comb Texture

[Surface texture shall be applied using an approved wire comb. The wire comb shall be operated mechanically with the length of the comb parallel to the pavement center line. The comb shall be capable of traversing the full width of the pavement in a single pass at a uniform speed and with a uniform pressure. Successive passes of the comb shall be overlapped the minimum necessary to obtain a continuous and uniformly textured surface. Texturing shall be completed before the concrete has dried to the point where the

surface and edges will be unduly torn, but after drying has progressed to the point where the serrations will not close up. Specific requirements for the texturing shall be as specified on the plans, but as general guidelines, the serrations shall be 1/16- to 3/16-inch deep, 1/16- to 1/8-inch wide, and spaced 1/4- to 1/2-inch apart.]

3.4.5.3 Broom Texturing

[Surface texture shall be applied using an approved hand or mechanical stiff bristle broom of a type that will produce uniform corrugations. For hand brooming, the brooms shall have handles longer than half the width of slab to be finished. The hand brooms shall be drawn transversely across the surface from the center line to each edge with slight overlapping strokes. For mechanical operations, the broom shall be operated with the length of the broom parallel to the pavement center line. The broom shall be capable of traversing the full width of the pavement in a single pass at a uniform speed and with a uniform pressure. Successive passes of the broom shall be overlapped the minimum necessary to obtain a uniformly textured surface. Brooms shall be washed thoroughly and dried at frequent intervals during use. Worn or damaged brooms shall be removed from the jobsite. Brooming shall be completed before the concrete has dried to the point where the surface will be unduly torn or roughened, but after drying has progressed enough so that the mortar will not flow and attenuate the sharpness of the corrugations. Specific requirements for the texturing shall be as shown, but in general the corrugations shall be uniform in appearance and approximately 1/16-inch to 1/8-inch in depth.]

3.4.5.4 Artificial Turf Texturing

[Surface texture shall be applied by dragging the surface of the pavement in the direction of concrete placement with an approved, full-width drag made with artificial turf. The leading transverse edge of the artificial turf drag will be securely fastened to a lightweight pole on a traveling bridge. At least 2 feet of the artificial turf shall be in contact with the concrete surface during dragging operations. Artificial turf shall be demonstrated by the Contractor to provide a satisfactory texture.

3.4.5.5 Surface Grooving

[The areas indicated in the drawings shall be grooved with individual grooves 1/4-inch deep and 1/4-inch wide at a spacing between groove centerlines [of 1-1/2 to 3 inches] [as indicated].

These grooves shall be cut perpendicular to the centerline. Before grooving begins, the concrete shall be allowed to obtain sufficient strength to prevent aggregate spalling. Grooves shall not be cut within 6 inches of a transverse joint or crack and they shall not be cut through longitudinal neoprene compression seals.]

3.4.5.6 Finishing Fiber Reinforced Concrete

[Finishing techniques specified for fixed form and slipform construction shall be used for fiber reinforced concrete with the following additions. Wood floats shall not be used. Magnesium floats shall be used for any needed minor surface corrections. The final finished surface shall not have more than 18 exposed fibers per square yard. If a jitterbug or rollerbug type finishing device is used to embed the fibers in the concrete matrix, care shall be taken to avoid overworking and bringing excess fines to the surface.]

3.4.6 Edging

After texturing has been completed, the edge of slabs along the forms, along the edges of slipformed lanes and at the joints, shall be carefully finished with an edging tool to form a smooth rounded surface of the required radius. Tool marks shall be eliminated, and the edges shall be smooth and true to line.

3.4.7 Outlets in Pavement

Recesses for the tie-down anchors, lighting fixtures, and other outlets in the pavement shall be constructed to conform to the details and dimensions shown. The concrete in these areas shall be carefully finished to provide a surface of the same texture as the surrounding area that will be within the requirements for plan grade and surface smoothness stated in paragraph PAVEMENT QUALITY CONTROL.

3.5 FORM REMOVAL

Forms shall remain in place at least 12 hours after the concrete has been placed. When conditions are such that the early-strength gain of the concrete is delayed, the forms shall be left in place for a longer period as directed. Forms shall be removed without injuring the concrete. Bars or heavy tools shall not be used against the concrete in removing the forms. Any concrete found defective after form removal shall be promptly satisfactorily repaired.

3.6 CURING

3.6.1 General Curing Requirements

Concrete shall be protected against loss of moisture and rapid temperature changes for at least 7 days from the beginning of the curing operation. Unhardened concrete shall be protected from rain and flowing water. All equipment needed for adequate curing and protection of the concrete shall be on hand and ready for use before actual concrete placement begins. Protection shall be provided as necessary to prevent cracking of the pavement due to temperature changes during the curing period. Curing shall be accomplished by either of the following methods or a combination thereof.

3.6.2 Moist Curing

Immediately after finishing operations have been completed and the concrete has set sufficiently to prevent marring of the surface, the forms and entire surface of the newly laid concrete shall be covered with wetted burlap or cotton mats. Burlap covers shall consist of two or more layers of burlap having a combined weight of 14 ounces or more per square yard in a dry condition. Cotton or burlap mats, after shrinkage, shall be at least 1 foot longer than necessary to cover the entire width and edge of the pavement lane. Adjacent mats shall overlap at least 6 inches. The mats shall be wetted thoroughly before placing and shall be kept continuously wet and in intimate contact with the pavement edges and surface for the duration of the required period. The surface of the newly laid concrete shall be kept moist by means of approved fog-spraying equipment until the burlap or cotton-mat coverings are in place.

3.6.3 Membrane Curing

A uniform coating of white-pigmented membrane-curing compound shall be applied to the entire exposed surface of the concrete as soon after

finishing as the free water has disappeared from the finished surface. Formed surfaces shall be coated immediately after the forms are removed and in no case longer than 1 hour after the removal of forms. Concrete shall not be allowed to dry before the application of the membrane. If any drying has occurred, the surface of the concrete shall be moistened with a fine spray of water, and the curing compound applied as soon as the free water disappears. The curing compound shall be applied to the finished surfaces by means of an approved automatic spraying machine. The spraying machine shall be self-propelled and shall straddle the newly paved lane. The machine shall have one or more spraying nozzles that can be controlled and operated to completely and uniformly cover the pavement surface with the required amount of curing compound. The curing compound in the drum used for the spraying operation shall be thoroughly and continuously agitated mechanically throughout the full depth of the drum during the application. Air agitation will be used only to supplement mechanical agitation. Spraying pressure shall be sufficient to produce a fine spray as necessary to cover the surface thoroughly and completely with a uniform film. Spray equipment shall be maintained in first-class mechanical condition, and the spray nozzle shall have an adequate wind guard. The curing compound shall be applied with an overlapping coverage that will give a two-coat application at a coverage of not more than 400 square feet per gallon for each coat. The application of curing compound by hand-operated pressure sprayers will be permitted only on odd widths or shapes of slabs where indicated and on concrete surfaces exposed by the removal of forms. When the application is made by hand-operated sprayers, the second coat shall be applied in a direction approximately at right angles to the direction of the first coat. The compound shall form a uniform, continuous, cohesive film that will not check, crack, or peel and that will be free from pinholes and other discontinuities. If pinholes, abrasions, or other discontinuities exist, an additional coat shall be applied to the affected areas within 30 minutes. Concrete surfaces that are subjected to heavy rainfall within 3 hours after the curing compound has been applied shall be resprayed by the method and at the coverage specified above. Areas where the curing compound is damaged by subsequent construction operations within the curing period shall be resprayed. Necessary precautions shall be taken to ensure that the concrete is properly cured at sawed joints, but that no curing compound enters the joints. The top of the joint opening and the joint groove at exposed edges shall be tightly sealed before the concrete in the region of the joint is resprayed with curing compound. The method used for sealing the joint groove shall prevent loss of moisture from the joint during the entire specified curing period. Approved standby facilities for curing concrete pavement shall be provided at an accessible location at the jobsite for use in the event of mechanical failure of the spraying equipment or other conditions that might prevent correct application of the membrane-curing compound at the proper time. Concrete surfaces to which membrane-curing compounds have been applied shall be adequately protected during the entire curing period from pedestrian and vehicular traffic, except as required for joint-sawing operations and surface tests, and from any other possible damage to the continuity of the membrane.

3.7 JOINTS

3.7.1 General Joint Requirements

Joints shall conform to the details indicated and shall be perpendicular to the finished grade of the pavement. Transverse expansion and contraction joints shall be straight and continuous from edge to edge of the pavement.

3.7.2 Longitudinal Construction Joints

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NOTE: If only a thin bonded rigid overlay is to be used, this paragraph will be deleted.

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Longitudinal construction joints between paving lanes shall be located as indicated. Dowels, keys, or keys and tie bars shall be installed in the longitudinal construction joints, or the edges shall be thickened as required and as indicated. Dowels and tie bars shall be installed in conformance with paragraph DOWELS AND TIE BARS. When the concrete is placed using stationary forms, metal forms securely fastened to the concrete form shall be used to form the keyway in the plastic concrete. When the concrete is placed using slipform pavers, the keyway shall be formed in the plastic concrete by means of metal forms permanently attached to the side forms or by means of preformed metal keyway liners, which are inserted during the slipform operations and shall be left in place. The dimensions of the keyway forms shall not vary more than plus or minus 1/8 inch from the dimensions indicated and shall not deviate more than plus or minus 1/4 inch from the middepth of the pavement. Longitudinal construction joints shall be edged and subsequently sawed to provide a groove at the top conforming to the details and dimensions indicated.

3.7.3 Transverse Construction Joints

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NOTE: If only a thin bonded rigid overlay is to be used, this paragraph will be deleted.

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Transverse construction joints shall be installed at the end of each day's placing operations and at any other points within a paving lane when concrete placement is interrupted for 30 minutes or longer. These joints shall be located at a planned joint, except in case of equipment breakdown. When concrete placement is halted, the transverse construction joint may be installed within the slab unit but not less than 10 feet from a planned transverse joint. Transverse construction joints shall be doweled as shown. When the construction joint is located at planned transverse joints, one-half of each dowel shall be painted and oiled to permit movement at the joint. These joints shall be edged and subsequently sawed to provide a groove at the top conforming to the details and dimensions indicated. When concrete placement is resumed, the planned joint spacing shall be used beginning with the first regularly scheduled transverse joint. When using slipform pavers, transverse construction joints shall be constructed by utilizing headers, hand placement, and finishing techniques. Pavement shall be constructed with the slipform paver as close to the header as possible and run out completely past the header.

3.7.4 Expansion Joints

Expansion joints shall be formed by means of a preformed filler material. The filler shall be securely held in position by means of approved metal supports, which shall remain in the pavement. A removable metal-channel cap

bar shall be used to hold the parts of the joint in proper position and protect the filler from damage during concreting operations. The cap bar shall be removable without damage to the pavement to provide a space for sealing of the joint. Adjacent sections of filler shall be fitted tightly together, and the filler shall extend across the full width of the paving lane in order to prevent entrance of concrete into the expansion space. Expansion joints shall be formed about structures and features that project through, into, or against the pavement, using joint filler of the type, thickness, and width indicated, and shall be installed in such manner as to form a complete, uniform separation between the structure and the pavement.

3.7.5 Contraction Joints

Transverse and longitudinal contraction joints shall be of the weakened-plane or dummy type and shall be constructed as indicated. Longitudinal contraction joints shall be constructed by sawing a groove in the hardened concrete with a power-driven saw in conformance with requirements for sawed joints unless otherwise approved. Transverse contraction joints shall be constructed in conformance with requirements for sawed joints or insert-type contraction joints, unless otherwise approved.

3.7.5.1 Sawed Joints

Sawed joints shall be constructed by sawing a groove in the concrete with a 1/8-inch blade to the full depth as indicated. After expiration of the curing period, the upper portion of the groove shall be widened by sawing to the width and depth indicated. The time of sawing shall vary depending on existing and anticipated weather conditions and shall be such as to prevent uncontrolled cracking of the pavement. Sawing of the joints shall commence as soon as the concrete has hardened sufficiently to permit cutting the concrete without chipping, spalling, or tearing. The sawed faces of joints will be inspected for undercutting or washing of the concrete due to the early sawing, and sawing shall be delayed if undercutting is sufficiently deep to cause structural weakness or excessive roughness in the joint. The sawing operation shall be carried on as required during both day and night regardless of weather conditions. The joints shall be sawed at the required spacing consecutively in the sequence of the concrete placement. A chalk line or other suitable guide shall be used to mark the alignment of the joint. The saw cut shall not vary more than 1/2 inch from the true joint alignment. Before sawing a joint, the concrete shall be examined closely for cracks, and the joint shall not be sawed if a crack has occurred near the planned joint location. Sawing shall be discontinued when a crack develops ahead of the saw cut. Workmen and inspectors shall wear clean, rubber-soled footwear, and the number of persons walking on the pavement shall be limited to those actually performing the sawing operation. Immediately after the joint is sawed, the saw cut and adjacent concrete surface shall be thoroughly flushed with water until all waste from sawing is removed from the joint. Any membrane-cured surface damaged during the sawing operations shall be resprayed as soon as the surface becomes dry. The sawing equipment shall be adequate in the number of units and the power to complete the sawing at the required rate. An ample supply of saw blades shall be available on the job before concrete placement is started, and at least one standby sawing unit in good working order shall be available at the jobsite at all times during the sawing operation.

3.7.5.2 Insert-Type Contraction Joints

Insert-type contraction joints shall be constructed by installing a contraction joint insert in the plastic concrete to form a weakened plane to induce cracking. Inserts shall be approved before installation. Inserts

shall be furnished in heights for the various depths of joints shown and in lengths equal to the width of the paving lane.

a. Equipment: The equipment for installing inserts shall be a machine equipped with a vibratory bar for cutting a groove in the plastic concrete for placement of the insert or for vibrating the insert into place at the prescribed joint location. Installation of the insert shall be to the required depth throughout the full width of the paving lane. Vibration units shall be so arranged that the vibration will be uniformly distributed throughout the bar. The intensity of vibration shall be adjustable as necessary to form a groove of proper size for the filler or for forcing the insert into the plastic concrete and consolidating the concrete around the in-place insert. For concrete placed by slipform pavers, the edges of the plastic concrete shall be supported to prevent slumping during the vibration and placement of inserts. The vibratory float shall be used following placement of the insert material in lieu of hand floating or troweling the finish.

b. Installation of Inserts: The insert shall be installed in the plastic concrete immediately following the final machine finishing with a maximum of two joint spacings between the finishing machine and the inserter. Additional straightedge and texturing operations shall be accomplished without disturbing the installed insert. Adjacent sections of the joint inserts within each slab unit shall be securely joined together, and the insert shall extend across the full width of the slab. The concrete shall be thoroughly consolidated against and for the full depth of the insert. The insert shall be perpendicular to the finished grade of the pavement and shall be straight in alignment at the prescribed joint locations shown, with the top of the insert flush or not more than 1/8 inch below the pavement surface. The insert equipment shall be available on the job in good condition before placement of concrete to ensure proper vibration and floating.

c. Insert Removal: After the expiration of the curing period a groove for the joint sealer shall be formed as specified below. The top portion of sawable preformed inserts shall be removed by sawing with a power saw to form a groove of required dimensions. The sawing shall abrade the concrete surfaces in the joint groove and to remove the insert. Nonsawable insert material shall be removed as prescribed by the manufacturers. The grooves shall have edges free of ravels and spalls. The grooves shall be straight from edge to edge of the pavement and shall not vary more than 1/2 inch from the alignment.

3.8 DOWELS AND TIE BARS

3.8.1 Fixed-Form Installation

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NOTE: If only a thin bonded rigid overlay is to be used, this paragraph will be deleted.

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Fixed-form installation of dowels and tie bars shall be by the bonded-in-place method. Tie bars and dowels shall be prepared and placed across joints where indicated, correctly aligned, and securely held in the proper horizontal and vertical position during placing and finishing operations, except that tie bars specified along longitudinal contraction joints shall

be installed in front of the paver by insertion into the unconsolidated concrete. Installation by removing and replacing dowels in preformed holes will not be permitted. Dowels in longitudinal and transverse construction joints shall be held securely in place parallel to the surface, as indicated, by means of devices fastened to the form. Dowels in expansion joints and tie bars and dowels installed within the paving lane shall be held securely in place, as indicated, by means of rigid metal frames or basket assemblies of approved type. The assemblies shall consist of a framework of metal bars or wires arranged to provide rigid support for the dowels and the tie bars throughout the paving operation, with a minimum of four continuous bars or wires extending across the paving lane. The dowels shall be welded to the assembly or held firmly by mechanical locking arrangements that will prevent the dowels from rising, sliding out, or becoming distorted during paving operations. The dowel assemblies shall be held securely in the proper location by means of suitable pins or anchors. When split dowels are used, the female portion of the split dowel shall be bonded in the initially placed pavement lane. The female portion of the split dowel shall be securely fastened to the pavement form and shall maintain the proper position and alignment of the dowel during concrete placement so that no mortar or other foreign material will enter the socket or coupling. Before the split dowels are assembled, the external and internal threads shall be cleaned thoroughly to remove all cement, cement mortar, grit, dirt, and other foreign matter. In the final assembly, a minimum torque of 200 ft-lbs shall be applied. The spacing of dowels in longitudinal construction joints shall be as indicated, except where the planned spacing is not maintained because of form length or interference with form braces, closer spacing with additional dowels shall be used. Dowels in longitudinal joints shall be omitted when the center of the dowel is located within a horizontal distance from a transverse joint equal to one-fourth of the slab thickness. The method used in holding dowels in position shall develop such accuracy that the error in alignment of any dowel from its required position after the pavement has been finished shall be not greater than 1/8-in/ft. The Contractor shall furnish an approved template for checking the position of the dowels. The portion of each dowel intended to move within the concrete or expansion cap shall be painted with one coat of red lead or blue lead paint. The painted portion shall be wiped clean and coated with a thin even film of lubricating oil before the concrete is placed. Pipe used as dowels shall be filled with a stiff sand-asphalt mixture or portland cement mortar, or the ends of the pipe dowels shall be fitted with tight-fitting plugs of an approved material extending into the pipe.

3.8.2 Slipform Installation

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NOTE: See Additional Note N.

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For concrete placed using slipform pavers, dowels and tie bars shall be placed in horizontal and vertical positions across the joints where indicated. Dowels in longitudinal construction joints shall be placed by bonding the dowels into holes drilled into the hardened concrete. When the grouted in-place method is used, holes approximately 1/8-inch greater in diameter than the dowels shall be drilled with rotary-type core drills that must be held securely in place to drill perpendicularly into the vertical face of the pavement slab. Dowels shall be bonded in the drilled holes using an epoxy resin material as specified in paragraph MATERIALS.

Installation procedures shall be adequate to ensure that the area around dowels is completely filled with epoxy grout. Dowels in expansion and contraction joints installed within the paving lane shall be held securely in place by means of rigid metal frames or basket assemblies of the type used in the method described in requirements for fixed-form installation. This method used for installing and maintaining dowels in position shall develop such accuracy that the error in alignment of any dowel from its required position shall be not greater than 1/8-in/ft. The Contractor shall furnish a template for checking the position of the dowels. Tie bars installed within the paving lane shall be held securely in place by means of rigid metal frames or basket assemblies of approved type as required by fixed-form installation. When tie bars are specified in longitudinal construction joints, bent tie bars shall be installed in front of the paver by insertion into the unconsolidated plastic concrete through a 26-gauge metal keyway liner. The bars shall not be installed in the plastic concrete after the concrete has been consolidated and the cross section formed. Tie bars shall not be installed in preformed holes in hardened concrete. The keyway liner shall remain in place and become part of the joint. When bending tie bars, the minimum radius of curvature recommended for the particular grade of steel cited in the appropriate standard shall be used. Before placement of the adjoining lane, the tie bars will be straightened.

3.9 SEALING JOINTS

Joints shall be sealed immediately following curing of the concrete or as soon thereafter as weather conditions permit. Sawing of filler-type joints shall be accomplished immediately before sealing of the joints. Joints shall be sealed as specified in Section 02580 JOINT SEALING IN CONCRETE PAVEMENTS FOR ROADS AND AIRFIELDS.

3.10 REMOVAL AND REPLACEMENT OF DEFECTIVE CONCRETE

Defective concrete shall be removed and replaced as specified herein with pavements of the thickness and quality required by these specifications. In no case shall the removal and replacement of concrete result in a slab less than a full paving lane width or a joint less than 10 feet from a regularly scheduled transverse joint. The adjacent pavement shall not be damaged and the existing keys or dowels shall left intact. When a portion of the unfractured slab is replaced, a saw cut 4-inches deep shall be made transversely across the slab in the required location, and the concrete shall be removed to provide an essentially vertical face in the remaining portion of the slab. Prior to placement of the fresh concrete, the face of the slab shall be cleaned of debris and loose concrete, and then thoroughly coated with epoxy-resin. The epoxy-resin coating shall be applied by scrubbing a thin coat into the surface with a stiff-bristle brush. Strips of polyethylene sheeting shall be placed on the vertical joint faces of adjacent slabs at the juncture with the slab to be patched as a bond-breaking medium. Placement of the fresh portland cement concrete shall be accomplished while the epoxy resin is still tacky and in such manner that the grout coating will not be removed.

3.11 INTEGRAL OR MONOLITHIC CURBS

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NOTE: Requirements of this paragraph apply to vehicular pavements only. Delete paragraph when specification is to be used for airfields and heliports. Non integral curbs and gutters shall be as

specified in section 02511, Concrete Sidewalks and Curbs and Gutters.

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3.11.1 General

Integral or monolithic curbs shall be constructed to dimensions and at locations indicated. Maximum nominal size of the coarse aggregate for curb construction shall be 1-1/2 inches.

3.11.2 Forms

Forms for curbs shall be of similar material to that used for pavement. The outside form shall be of a depth equal to the combined depth of the integral curb and the pavement slab. The form shall be a built-up section, the lower portion equal to the depth of the pavement slab and the upper portion equal to the depth of the integral curb. The built-up form shall be designed to assure rigid connection between the lower and the upper portions. The inside curb-face form shall have a batter from the top of the curb to the finished pavement surface as indicated. The inside curb form shall be securely fastened to and supported by the outside form. Fastenings shall not obstruct the satisfactory finishing and edging of the top of the curb and shall permit early removal of the face form.

3.11.3 Placing

The concrete curb shall be placed as soon as practical after the slab is placed, but in no case shall the time between the placing of the slab and the placing of the curb exceed 45 minutes. The concrete shall be thoroughly spaded or vibrated until well compacted and until a good bond is obtained between the curb and the slab. If it is impractical to complete the integral curb simultaneously with the pavement slab, No. 5 deformed tie bars 7 inches long shall be embedded vertically in the slab at 1-foot intervals so as to extend 2 inches into curb. While the slab is still green, the surface shall be dapped approximately 1 inch below the screeded surface for the full width of the curb, leaving a recess roughened surface to provide the bond for the curb section.

3.11.4 Transverse Joints

Transverse joints shall be of the type and construction specified for transverse joints for the pavement slab on which the curb is placed. Pavement joints shall extend through the curb except that horizontal dowels will not be required between joints in the curb.

3.11.5 Finishing Curbs

The top of the curb shall be floated to compact the concrete thoroughly and produce a smooth even surface. Edges of the curb and joints shall be rounded by using appropriate edging tools. Vertical edges of joints shall be dressed when the curb form is removed. While the concrete is green, the top and face of the curb shall be finished by rubbing the surface with a wood or concrete rubbing block and water until all blemishes, form marks, and tool marks are removed. Ample water shall be used during the rubbing to avoid a plastered condition. The rubbed surface shall then be brushed with a fine-textured brush to obtain a uniform sandy texture, free from humps, sags, and other irregularities. The top and face of the curb shall not vary more than 1/8-inch from the edge of a 10-foot straightedge, except at grade

changes or curves. Visible surfaces and edges of the finished curb shall be free of blemishes, form and tool marks, and shall be uniform in color, shape, and appearance.

3.12 CONTRACTOR QUALITY CONTROL

3.12.1 General

The Contractor shall perform the inspection and tests as described below. Based upon the results of these inspections and tests, the Contractor shall take the actions and submit reports as required below, and shall perform any additional tests necessary to ensure that the requirements of these specifications are met.

3.12.2 Inspection Details and Frequency of Testing

3.12.2.1 Fine Aggregate

a. Grading: Twice during each shift when the concrete plant is operating, one sieve analysis and fineness modulus determination shall be made in accordance with ASTM C 136 and COE CRD-C 104 for the fine aggregate or for each fine aggregate, if it is batched in more than one size of classification. The location at which samples are taken will be selected by the Contractor as the most advantageous for control.
b. Fineness Modulus Control Chart: Results of the fineness modulus determination shall be grouped in sets of three consecutive tests, and the average and range of each group plotted on a control chart. The upper and lower control limits for the average shall be drawn 0.10 units above and below the average fineness modulus of all samples previously taken, and the upper control limit for the range shall be 0.28.

c. Moisture Content: At least two direct measurements of moisture content shall be made per week to check the calibration of the meter. Variability within a 1- or 8-hour period shall be determined by meter readings. In the opinion of the Contracting Officer, when the electric moisture meter is not operating satisfactorily, at least two pairs of tests for moisture content in accordance with ASTM C 70, ASTM C 566, or COE CRD-C 112 will be made during each 8-hour period of mixing plant operation. The two tests in each pair shall be spaced 1 hour apart, and the times for the pairs shall be selected randomly within the shift. An additional test shall be made whenever the slump is excessive.

3.12.2.2 Coarse Aggregate

a. Grading: Twice during each shift in which the concrete plant is operating a sieve analysis shall be made in accordance with ASTM C 136for each size of coarse aggregate. Samples shall be taken from the batch plant bins. Each test record shall show the results of the current test and the average results of the five most recent tests including the current test. Tests at other locations, when necessary for control, shall be recorded also. For these tests the Contractor may adopt limits for control coarser than the specification limits to allow for degradation during handling. Where facilities are available to test samples five times as large as those required in ASTM C 136, no averaging is necessary. When, in the opinion of the Contracting Officer, the coarse aggregate particle shape is deficient, daily tests shall be made in accordance with COE CRD-C 119.

b. Moisture Content: A test for moisture content of each size of coarse aggregate shall be made at least once per shift. When two

consecutive readings for the smallest size coarse aggregate differ by more than 1 percent, the frequency of testing shall be increased to that specified for fine aggregate.

3.12.2.3 Scales

The accuracy of the scales shall be checked by test weights, as directed by the Contracting Officer, for conformance with the applicable requirements of NIST PB 90-184961. Such tests shall be made whenever there are variations in properties of the fresh concrete, which could result from batching errors. Once a week the accuracy of each batching device shall be checked during a weighing operation by noting and recording the required weight and the actual weight batched.

3.12.2.4 Batch-Plant Control

When the concrete plant is operating, the measurement of all constituent materials including cement, each size of aggregate, water, and admixtures shall be continuously controlled. The aggregate weights and the amount of water added to compensate for free moisture in the aggregates shall be adjusted as necessary. The amount of the air-entraining agent shall be adjusted to control the air content within specified limits. A report shall be prepared indicating the type and source of cement used, the amount and source of admixtures used, the aggregate source, the required aggregate and water weights per cubic yard, the amount of water as free moisture in each size of aggregate, and the batched aggregate and water weights per cubic yard for each class of concrete batched during the plant operation.

3.12.2.5 Concrete

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NOTE: Provisions of the guide specification relative to field-test specimens are applicable to all airfield paving projects and other paving projects requiring more than 1600 cubic yards of concrete. For smaller projects, exclusive of airfield pavements, the second paragraph will be used in lieu of the first paragraph of subparagraph "b."

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a. General: Concrete samples shall be furnished by the Contractor and shall be taken by the Contractor in the field to determine the slump, air content, and strength of the concrete. Test beams shall be made for determining conformance with the strength requirements of these specifications and, when required, for determining the time at which pavements may be placed into service. The air content shall be determined in accordance with ASTM C 231 or ASTM C 172 as applicable. Slump tests shall be made in accordance with ASTM C 143. Test beams shall be molded and cured in accordance with ASTM C 31 and as specified below. Steel beam molds shall be used for molding the specimens. The Contractor shall furnish all materials, labor, and facilities required for molding, curing, testing, and protecting test beams at the site. Curing facilities for test beams shall include furnishing and operating water tanks equipped with temperature-control devices that will automatically maintain the temperature of the water at 73 plus or minus 5 degrees F. The Contractor shall furnish and maintain at the site

boxes or other facilities suitable for storing the specimens while in the mold at a temperature of 73 plus or minus 10 degrees F. Tests of the fresh concrete and of the hardened concrete beams will be made by and at the expense of the Contractor.

b. Specimens for Strength Tests: One set of [_____] test beams shall be made for every 100 cubic yards or less of concrete placed daily. Test beams shall be molded and cured in conformity with ASTM C 31, and tested in accordance with ASTM C 78.]

[One set of six test beams shall be made for each 500 cubic yards, or fraction thereof, of concrete placed during each shift. However, at the start of paving operation and when the aggregate source, aggregate characteristics, or mixture proportions are changed, additional groups of test beams shall be required until the Contracting Officer is satisfied that the concrete mixture being used complies with the strength requirements of these specifications. Test ages for airfield pavements will be 7, 14, and 90 days, and for pavement other than airfield the test ages will be 7, 14, and 28 days. Specimens shall be tested in accordance with ASTM C 78. The test results shall show that 80 percent of the consecutive individual tests equal or exceed [_____] psi at 14-day age. If the average of any five consecutive 14-day strengths or more than 20 percent of the individual tests is less than [_____] psi, the mixture proportions shall be changed to increase the strength. The average of any five consecutive 90-day strengths shall equal or exceed [_____] psi.]

Seven-day strengths shall be taken for the purposes of determining the early strength of concrete for construction loading and are not to be considered in evaluating the 14-, 28-, or 90-day strength of the concrete.

c. Air Content: Two tests for air content shall be made on randomly selected batches of concrete for each 500 cubic yards, or fraction thereof, of concrete placed during each shift. Additional tests shall be made when there is excessive variation in workability. The average of each set of two tests shall be plotted on a control chart on which the average is set at 6 percent and the upper and lower control limits at 7 and 5 percent. The range shall be plotted on a control chart on which the upper control limit shall be 2 percent.

d. Slump: Two slump tests shall be made on randomly selected batches of each class of concrete for each 500 cubic yards, or fraction thereof, of concrete placed during each shift production. Additional tests shall be made when there is excessive variation in workability. The average of each set of two tests shall be plotted on a control chart on which the average is set as determined by the Contracting Officer and the upper and lower control limits set at 1 inch above and below the average. The range shall be plotted on a control chart on which the upper control limit shall be 2 inches.

3.12.2.9 Hot-Weather Placing

The Contractor shall take and record the temperature of the concrete mixture at 30-minute intervals during hot-weather placement.

3.12.3 Action Required

3.12.3.1 Fine Aggregate

a. Grading: When the amount retained on any sieve is outside the specification limits, the fine aggregate shall be resampled and

retested. If there is another failure on the same sieve, the fact shall be reported immediately to the Contracting Officer. All such tests shall be included in the control charts. Whenever a point, either for the average or the range, is beyond one of the control limits, the frequency of testing shall be doubled. If two consecutive points are beyond the control limits, the process shall be considered out of control. The Contracting Officer shall be notified, and immediate steps shall be taken to rectify the situation. After two consecutive points have fallen within the control limits, testing at the normal frequency will be resumed.

b. Moisture Content: Whenever the moisture content of the fine aggregate changes by 0.5 percent or more, the scale settings for the fine aggregate batcher and water batcher shall be adjusted (directly or by means of a moisture compensation device). If, at any time, the requirements for moisture variation are not met, the Contracting Officer shall be notified and immediate steps shall be taken to reduce the variation.

3.12.3.2 Coarse Aggregate

a. Grading: When the amount passing any sieve is outside the specification limits, the coarse aggregate shall be resampled and retested.

If the second sample fails on the same sieve, that fact shall be reported to the Contracting Officer. When two consecutive averages of five tests (or two consecutive tests where large samples are used) are outside of the specification limits, that fact shall be reported to the Contracting Officer and immediate steps shall be taken to correct the grading.

b. Moisture Content: Whenever the moisture content of the smallest size of coarse aggregate changes by 0.5 percent or more, the scale settings for the aggregate batcher and water batcher shall be adjusted (directly or by means of a moisture compensation device). If, at any time, the requirements for moisture variation are not met, the Contracting Officer shall be notified and immediate steps taken to reduce the variation.

c. Particle Shape: When testing for particle shape is required, two consecutive failures in the same sieve size shall be reported immediately to the Contracting Officer, who shall provide instructions as to the necessity for corrective action.

3.12.3.3 Scales

Whenever either the weighing or the batching accuracy is found not to comply with specification requirements, the plant shall not be operated until necessary adjustments or repairs have been made. Discrepancies in recording accuracies shall be corrected immediately.

3.12.3.4 Concrete

a. Strength: The results of the 14-day strength test shall be plotted on a control chart. When more than 20 percent of the consecutive individual tests are less than the specified value or the average of any five consecutive tests is less than the specified value, the Contracting Officer shall be notified and the mixture proportions changed to increase the strength of the mixture. When the average of any five consecutive 28-or 90-day-age tests is less than the specified strength, care shall be taken to define the area of low-strength pavement and the

area removed and replaced in accordance with requirements of paragraph REMOVAL AND REPLACEMENT OF DEFECTIVE CONCRETE.

b. Air Content: Whenever points on the control chart approach the upper or lower control limits, an adjustment shall be made in the amount of the air-entraining admixture batched. If a single test result is outside the specification limit, such an adjustment is mandatory. As soon as practicable after each adjustment, another test shall be made to verify the correctness of the adjustment. Whenever a point falls above the upper control limit for the range, the dispenser shall be calibrated to ensure that it is operating correctly and with good reproducibility. Whenever two consecutive points, either for the average or the range, are outside the control limits, the Contracting Officer shall be notified.

c. Slump: Whenever points on the control chart approach the upper or lower control limits, an adjustment will be made in the batch weight of water and fine aggregate. When a single slump is outside the control limits, such an adjustment is mandatory. As soon as practicable after each adjustment, another test shall be made to verify the correctness of the adjustment. Whenever the slump departs more than 1-1/2 inches from that stipulated by the Contracting Officer, the concrete shall not be delivered to the paver. Whenever two consecutive slump tests that were made during a period when there was no adjustment of batch weights produce a point on the control chart for a range above the upper control limit, the slump shall be considered out of control and the additional testing for aggregate moisture content required above shall be undertaken.

3.12.3.7 Mixer Performance

At the start of concrete placing, and at least once every 3 months when concrete is being placed, the uniformity of concrete shall be determined. The initial and every fourth test shall be performed in accordance with the regular test of COE CRD-C 55. Other tests shall be performed in accordance with abbreviated tests of COE CRD-C 55. Whenever adjustments in the mixer or increases in mixing times are necessary because of failure of any mixer to comply, the mixer shall be retested after adjustments. For complete testing, three different batches of concrete shall be tested. For abbreviated tests, one batch shall be tested. Results of tests shall be reported in writing.

3.12.4 Reports

Test reports shall be made weekly and shall be submitted to the Contracting Officer within 3 days after the end of each weekly reporting period. Each weekly report shall include the updating of control charts covering the entire period from the start of the construction season through the current week. During periods of cold weather protection, reports of pertinent temperatures shall be made daily. These requirements do not relieve the Contractor of the obligation to report certain failures immediately as required in preceding paragraphs. Such reports of failure and the action taken shall be confirmed in writing in the routine reports. The Contracting Officer shall have the right to examine all Contractor quality control records.

3.13 PAVEMENT QUALITY CONTROL

3.13 PAVEMENT SURFACES (ROADS AND STREETS)

Road and street pavements shall be smooth and true to grade and cross section. When tested with a 10-foot straightedge on lines 5 feet apart parallel with the center line of the pavement, the surface shall not vary more than 1/8 inch from the testing edge of the straightedge.

3.13 PAVEMENT SURFACES (AIRFIELDS)

Variation in plan grade, surface smoothness, and edge slump of the pavement shall be within the tolerances specified as follows.

a. Plan Grade: The finished surfaces of airfield runway, taxiway, and apron pavements shall vary not more than 0.04 foot above or below the plan grade line or elevation indicated. However, the above 0.04-foot deviation from the approved grade line and elevation will not be permitted in areas where closer conformance with the planned grade and elevation is required for the proper functioning of appurtenant structures. The finished surfaces of new abutting pavements shall coincide at their juncture. Where a new pavement abuts an existing pavement, a transition pavement strip of the type and dimensions indicated shall be installed.

b. Surface Smoothness: The finished surfaces of airfield and heliport pavements shall have no abrupt change of 1/8 inch or more and shall be within the tolerances specified below when checked with an approved 12-foot straightedge.

SURFACE SMOOTHNESS-AIRFIELD PAVEMENTS

Item No.	Pavement Category	Direction of Testing	Tolerances Inches
1	Runways and taxiways	Longitudinal Transverse	1/8 1/4
2	Calibration hardstands and compass swinging bases	Longitudinal Transverse	1/8 1/8
3	All other airfield and helicopter paved areas	Longitudinal Transverse	1/4 1/4

3.13.1.2 Edge Slump

When slip-form paving is used, 85 percent of the pavement will not have an edge slump exceeding 1/4 inch, and 100 percent of the pavement shall not have an edge slump exceeding 3/8 inch as determined in accordance with the measurements as established under edge slump determination requirements. The area affected by the downward movement of the concrete along the pavement edge shall be limited to not more than 18 inches from the edge. The use of slipform paving equipment and procedures that fail to provide pavement edges within the above limitations shall be discontinued, and the pavements will be constructed by means of standard paving procedures with fixed forms.

3.13.2 Surface Tests

[Parking area, motor-pool and motor-storage area, repair yard and open-storage area pavements shall be tested with a 10-foot straightedge on lines 5 feet apart parallel with, and at right angles to, the center line of the paved area. The surface shall not vary more than 1/4 inch from the testing edge of the straightedge.]

[The finished surface of pavements shall be tested in accordance with the requirements specified below:

3.13.2.1 Straightedge

The Contractor shall furnish and maintain at the jobsite, in good condition, one 12-foot straightedge in addition to the number required by the Contractor for each paving spread for testing the hardened portland-cement concrete surfaces. These straightedges shall be constructed of aluminum or magnesium alloy and shall have blades of box or box-girder cross section with flat bottom, adequately reinforced to ensure rigidity and accuracy. Straightedges shall have handles for operation on the pavement. Where devices other than straightedges are approved for surface-smoothness determinations, the Contractor shall furnish and maintain at the jobsite, in good working condition, one such device for each paving spread.

3.13.2.2 Plan Grade Tests

Each pavement category will be checked for conformance with plan grade requirements. For the purpose of making grade conformance tests, the pavements will be subdivided into approved areas such as a 1000-foot section of the full width of a runway or taxiway and equivalent apron areas as mutually agreed to in writing between the Contractor and Contracting Officer before the commencement of paving operations. The finished surface of each approved pavement area will be tested by the Contracting Officer by running lines of levels at intervals of 25 feet or less longitudinally and transversely to determine the elevation of the completed pavement.

3.13.2.3 Surface-Smoothness Tests

After the concrete has hardened sufficiently to permit walking thereon, but not later than 36 hours after placement, the surface of the pavement shall be tested by the Contractor with a straightedge or other approved device. Deviations greater than specified tolerances caused by the edge slump along slipformed longitudinal construction joints shall not be considered in smoothness determinations in the transverse direction. Deviations greater than specified tolerances caused by high areas along slipformed longitudinal construction joints shall be considered in smoothness determinations in the transverse direction. The entire area of the pavement shall be tested in both a longitudinal and a transverse direction on parallel lines 5 feet or less apart. The straightedge shall be held in contact with the surface and moved ahead one-half the length of the straightedge for each successive measurement. Straightedge lines shall be carried continuously across joints. The height of high areas on pavement surfaces shall be determined by placing the center of the straightedge at the center of high areas, rocking the straightedge until one end comes in contact with the pavement, then measuring the distance between the pavement surface and the bottom of the straightedge at the opposite end, and taking one-half the distance as the height of the high area.

3.13.2.4 Edge Slump Tests

The edge slump shall be determined at each edge of each paving lane constructed using a sliding form with the straightedge placed transversely to the direction of paving and the end of the straightedge located at the edge of the paving lane. Measurements shall be made at 5-to 25-foot spacings commencing at the header where paving is initiated. The measurements will be made by the Contracting Officer and properly referenced in accordance with established paving lane identification and stationing.

3.13.3 Corrections

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NOTE: In preparing contract specifications for road, street, and open-storage concrete pavements, edit the following paragraphs appropriately.

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3.13.3.1 Plan Grade and Surface Smoothness

High areas shall be reduced either by rubbing the freshly finished concrete with Carborundum brick and water when the concrete is less than 36 hours old or by grinding with an approved surface grinding machine after the concrete is 36 hours old. The area corrected by grinding shall not exceed 5 percent of the area of any integral slab, and the depth of grinding shall not exceed 1/4 inch. Areas requiring grade or surface smoothness corrections in excess of the limits specified above shall be removed and replaced in conformance with the requirements of paragraph REMOVAL AND REPLACEMENT OF DEFECTIVE CONCRETE. Areas exceeding 25 square feet that have been corrected by rubbing or grinding shall be retextured by transverse grooving. The grooves shall be 1/8- by 1/4-inch on 2-inch centers and tapered to zero depth within the noncorrected surface. All areas in which rubbing or grinding has been performed will be subject to the thickness tolerance requirements specified.

3.13.3.2 Edge Slump

When edge slump exceeding the edge slump tolerance, additional straightedge measurements will be made, if required, to define the linear limits of the excessive slump. The concrete within these limits of excessive edge slump shall be removed and replaced in conformance with requirements of paragraph REMOVAL AND REPLACEMENT OF DEFECTIVE CONCRETE. Partial slabs removed and replaced shall extend across the full width of the pavement lane, and both the section of the slab removed and the section remaining in place shall have a minimum length of 10 feet to the nearest scheduled transverse joint. Adding concrete to the edge or otherwise manipulating the concrete after the sliding form has passed shall not be used as a method for correcting excessive edge slump.

3.13.4 Pavement Thickness

Permissible deficiency in pavement thickness will be up to but not including 1/4-inch of the specified thickness without a reduction in contract unit price.

3.13.5 Thickness Testing

The thickness of the pavement shall be determined by measurements made on cores drilled in the pavement with a minimum of one test per 2,500 linear feet of paving and selected in a random fashion within 7 days after placement of the concrete. Measurements of individual cores shall be performed in accordance with ASTM C 174. Refilling of core holes shall be performed immediately after drilling.

3.13.6 Adjustment and Correction of Thickness Deficiency

When core measurement indicates that the pavement is deficient in thickness 1/4 inch or more, additional cores will be drilled along the center line of the lane at 25-foot intervals on each side of the deficient core until the cores indicate that the deficiency in thickness is less than 1/4 inch. When the deficiencies in thickness for a series of cores are between 1/4 and 3/4 inch (1/2 inch for pavements 8 inches or less in thickness), the average thickness shall be established from an average of all core thicknesses, and an adjusted unit price, as provided in paragraph PAYMENTS, will be paid for the area of pavement showing deficiency in thickness. The area of pavement for the adjusted unit price shall be considered to be the full paving lane width and midway between cores showing deficient thickness and those meeting the permissible deviations. When any core shows a deficiency in thickness of 3/4 inch (1/2 inch for pavements 8 inches or less in thickness) or more, the area represented by that core shall be removed and replaced with pavement of the indicated thickness in conformance with requirements of paragraph REMOVAL AND REPLACEMENT OF DEFECTIVE CONCRETE. The area represented by the core shall be the full paving lane width midway between adjacent cores or to the transverse joint if such a joint falls between the cores. If the Contractor believes that the cores and measurement taken are not sufficient to indicate fairly the actual thickness of the pavement, additional cores and measurements will be taken.

3.14 CLEAN-UP

After completion of the protection and curing period, insulating and curing materials shall be removed and disposed of off the site. Concrete surfaces shall be swept and washed free of stains, discolorations, and loose particles.

3.15 PAVEMENT PROTECTION

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NOTE: For cold-weather construction when field-strength data may be necessary to permit the opening of the pavement or portions thereof to construction traffic before 14 days, as permitted under this paragraph of the guide specification, the first paragraph will be included in contract specifications.

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[Specimens for Determining Time of Opening Pavement: Test groups of at least three beams shall be taken, as required, from concrete placed in designated areas. The beams of each test group shall be made from a single batch of concrete. The test beams shall be cured in accordance with ASTM C 31.]

The Contractor shall protect the pavement against all damage prior to final acceptance of the work by the Government. Traffic shall be excluded from the pavement by erecting and maintaining barricades and signs until the concrete is at least 14 days old, or for a longer period if so directed. However, in paving intermediate lanes between newly paved lanes, operation of the hauling equipment will be permitted on the pavement after the pavement has been cured for 7 days and the joints have been sealed or otherwise protected. Also, the subgrade planer, concrete finishing machines, and similar equipment will be permitted to ride upon the edges of previously constructed slabs when the concrete has attained a minimum flexural strength of 400 psi and adequate means are furnished to prevent damage to the slab edge. The pavement carrying traffic or equipment shall be kept clean, and spillage of materials or concrete shall be cleaned up immediately upon occurrence. For fill-in lanes, equipment will be used that will not damage or spall the edges or joints of the previously constructed pavement.

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ADDITIONAL NOTES

NOTE A: For additional information on the use of all CEGS, see CEGS-01000 CEGS GENERAL NOTES.

NOTE B: In preparing contract specifications for concrete pavement, the Contracting Officer will use TM 5-822-7/AFM 88-6, Chapter 8, STANDARD PRACTICE FOR CONCRETE PAVEMENTS. If economically feasible use Steel Fiber Reinforced Concrete.
State Highway specifications may only be used for nonorganizational parking, roads, streets, and driveways where the paving index is less than 5.

All organizational vehicle parking and airfield concrete pavements shall use the Corps of Engineers Guide Specifications without exception.

NOTE C: In general, this specification as written for concrete pavements is applicable to lean concrete bases (also popularly known as "Econocrete") since materials and construction procedures are similar. Those sections pertaining to texturing, reinforcing, dowels, tie bars, and joint sealing can be deleted since they are not applicable. The lean concrete base may or may not require sawcut construction joints depending on the engineer's purpose in using the base and the planned surfacing construction. Generally, all longitudinal construction joints are butt joints without keys, dowels, or tie bars. Lean concrete base differs from conventional paving concrete primarily due to lower cement contents.

Sometimes a poorer quality aggregate may be used but the durability of this aggregate under the project's freezing and thawing conditions should be investigated. Other considerations such as popouts or

easily polished aggregates are of less concern in a base than in a surface pavement. Aggregate quality requirements may be relaxed for these considerations. The dividing line between a stabilized base and lean concrete base is not clear. Generally, if the material's compressive strength is less than 1500 psi, the flexural strength is less than 350 psi, or the amount of material passing the number 200 sieve is allowed to increase appreciably, it should be treated as a stabilized base rather than lean concrete base.

NOTE D: A choice must be made between Aggregates and Recycled Aggregates. Approved aggregate sources paragraph for SPECIAL CLAUSES is given in ER 1180-1-1, paragraph 7-670.2. Evaluation of aggregates and concrete mix designs for projects requiring 1600 cubic yards or less of concrete (except airfield paving) will be performed by an approved commercial testing laboratory at no expense to the Government. In this case, the second bracketed paragraph and table will be used.

NOTE E: Recycled aggregate made by crushing old concrete pavement is acceptable as aggregate in new concrete. However, it must meet all the requirements for gradation and quality given in the specification for natural aggregates and crushed stone. All steel must be removed from the recycled concrete aggregate, and if the aggregate is contaminated with base or subgrade material, it should be washed. If the old concrete pavement is "D" cracked, then all of the recycled aggregate should be crushed so that all particles pass the 3/4-inch sieve. If reclaimed portland cement concrete is to be used, the following paragraphs show additions and modifications required in the main specification.

NOTE F: This guide specification places the responsibility for acceptance sampling and testing during construction on the Government; however, for projects requiring 1600 cubic yards or less of concrete (except airfields and heliport pavements) sampling and testing will be the Contractor's responsibility at no expense to the Government. A sample of each of the materials used on the job will be taken by the Contractor under the supervision of the Contracting Officer and will be retained by the Government. Certified copies of the test results shall be submitted to the Contracting Officer. The paragraph will be revised accordingly.

NOTE G: Selection of cementitious materials is complex and requires study and knowledge of soil, aggregates, climate, and availability of cementitious materials. These notes provided herein are brief

reminder statements, and in no way provide sufficient guidance for making proper selections in this specification. The designer shall supplement these notes by using ACI 201.2R and ACI 225R extensively when selecting cementitious materials for a project specification.

Should low-alkali portland cement be required and not economically available in the project area, local area portland blast-furnace slag cement, portland-pozzolan cement, slag cement, slag-modified portland cement or a pozzolan with portland cement should be specified and tested in accordance with ASTM C 441. When tested in accordance with ASTM C 441 using test method ASTM C 227, the alternative cementitious material will be acceptable if expansion is less than 0.10 percent at six months. A seven-month to nine-month lead time shall be required to obtain the test results required for material approval or disapproval.

Should Type V portland cement be required for pavements subject to severe sulfate exposure, and Type V is not economic in the project area, local area suitable pozzolan with portland cement or slag with portland cement or other sulfate-resistant cementitious materials should be investigated by the designer. For very severe sulfate exposure, Type V portland cement blended with select pozzolans or select ground granulated blast-furnace slags may improve resistance to sulfate exposure. The use of alternate sulfate-resistant cementitious materials will be acceptable if expansion is less than 0.10 percent at six months when tested in accordance with ASTM C 1012. A seven-month to nine-month lead time shall be required to obtain the test results required for material approval or disapproval. Moderate sulfate exposure, severe sulfate exposure, and very severe sulfate exposure shall be as defined in ACI 201.2R.

NOTE H: For portland blast - furnace cement, portland - pozzolan cement and pozzolan-modified cement, should the pavement be subject to moderate sulfate exposure, "MS" should be specified. If alkali-reactive aggregates are a problem to the local area, "with mortar-bar expansion optional requirements" should be included.

NOTE I: Portland cement Type I or Type II is normally specified for paving applications. Should the pavement be subject to moderate sulfate exposure, Type II should be specified. Should the pavement be subject to severe sulfate exposure, Type V should be specified. Where alkali-reactive aggregates as defined in ASTM C 33 are to be used, "low-alkali"

should be specified as defined in ASTM C 150. If local area cement suppliers or cement producers have a history of cement false-set problems, the false-set requirement shall be included as defined in ASTM C 150.

NOTE J: Crushing the gravel tends to improve quality and bond characteristics and generally results in higher flexural strength of concrete. When mixture proportioning studies or local experience indicates that low flexural strength will be obtained with an uncrushed gravel, the possibility of obtaining higher strength by crushing the gravel will be investigated. When desirable, to limit coarse aggregate to crushed materials, modify the paragraph appropriately.

Special attention will be given to the existence of magnetite in granites, high-iron minerals in traprock, pyrite in limestone, and free iron or iron oxide in slag aggregate. When the paving of calibration hardstands is required, include the second paragraph as additional requirement for coarse aggregates.
NOTE K: Delete the inappropriate table.

Table on Limits of Materials for Airfield Pavements: Select appropriate percentage by weight in accordance with local experience with "popouts" and the following:

Weather Severity	Air Freezing Index Coldest Year in 30(1)	Average Precipitation for a Single Month During Period(1) Month Before Average Date of First Killing Frost to Average Date of Last Killing Frost
Moderate	500 or less	Any amount
Moderate(2)	501 or more	Less than 1 inch
Severe	501 or more	1 inch or more

(1) Calculated as described in TM 5-818-2. See ASTM C 33 for simplified map of CONUS weather severity.

(2) In poorly drained areas, the weather should be considered severe even though the other criteria indicate a rating of moderate.

NOTE L: Special attention will be given to the existence of magnetite in granites, high-iron minerals in traprock, pyrite in limestone, and free iron or iron oxide in slag aggregate. When the paving of calibration hardstands is required, include the second

paragraph as additional requirement for fine aggregates. If reclaimed portland cement concrete is used edit the following appropriately.

NOTE M: The specific type of texturing to be used depends on the planned use of the pavement, and specific texturing requirements should be noted on the plans. Artificial turf, burlap-drag, and broom finishing are all generally acceptable for most pavements. The Air Force requires wire comb or grooving for runways and high-speed taxiways. Edit the following paragraphs to match the specific project requirements.

NOTE N: Mechanical insertion of longitudinal dowel bars is unsatisfactory for airfield pavements. When inserted, the larger dowel bars cause displacement of the concrete, changing the pavement's surface smoothness. Insertion technology is improving; and mechanical insertion may be appropriate on a trial basis for some road or street pavements where surface smoothness tolerances are not critical. If only a thin bonded rigid overlay is to be used, this paragraph shall be deleted.

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